THE MYSTERIES OF THE FLOWERS

HERBERT W. FAULKNER

LIBRARY
UNIVERSITY OF
CALIFORNIA
SAN DIEGO

Margaret Kimball.

ARDENSIDE BOOKSHOP
80 Dartmouth Street
BOSTON, MASS.

THE MYSTERIES OF THE FLOWERS

THE FLAME AZALEA

THE MYSTERIES OF THE FLOWERS

BY

HERBERT WALDRON FAULKNER, PH. B., M.E.

WITH EIGHT PLATES IN COLOR AND ONE HUNDRED AND FORTY-THREE DRAWINGS BY THE AUTHOR

NEW YORK

FREDERICK A. STOKES COMPANY

PUBLISHERS

Copyright, 1917, by
FREDERICK A. STOKES COMPANY

All rights reserved, including that of translation into foreign languages

TO A FLOWER

A Flower I found in Cornwall, near the Sea,
Bore it away to flourish in my home,
Nurtured and tended it with loving care.
And here its fragrant blooms rejoice our hearts,
Inspire our souls, and beautify our lives.
To that dear Flower I dedicate my work.

H. W. F.

Washington, Conn.,
January 1, 1917.

CONTENTS

CHAPTER I

INTRODUCTION

PAGE

The Utility of Cross-Fertilisation 12

CHAPTER II

PISTILLATE FLOWERS AND STAMINATE FLOWERS

Dicœcious Flowers 16
Asparagus 16
Devil's Bit, or Blazing Sun 17
Jack-in-the-pulpit 18
Virgin's Bower 24
Tall Meadow-rue 25
Goat's-beard 26
Eel Grass; Tape Grass 26
Moncœcious Flowers 28
The Gourd Family 28
Wild Balsam-apple 29
Arrowhead 30

CHAPTER III

PERFECT FLOWERS

Windflower; Wood-anemone 34
White Water-lily 35
Common St.-John's-wort 35
Marsh St.-John's-wort 35
Common Mallow 35
Hardhack; Steeple-bush 36

PAGE

Flowering Dogwood 36
The Spiderwort 36
Hedge Bindweed 37
Marsh Marigold 40
Field Mustard 41
Common Elder 41
Water Plantain 42
Yellow Star Grass 42
Virginia Lungwort 43
Forget-me-not 43
Pistils Longer than Stamens 44
Pink Azalea 44
White or Clammy Azalea 45
Trumpet Honeysuckle 46
Great Laurel 47
Mountain Laurel 47
Horse-Chestnut 48
Shinleaf 48
Wake-robin 49
Blue-eyed Grass 50
Swamp Rose-mallow 50
Pitcher-plant 51
Quaker-lady, or Bluets 54
Garden Geranium 55
Partridge Berry 56
Stamens and Pistils developing at different times 57
Stigmas developing before stamens 59
English Plantain; Ripple Grass; Rib Grass 59
Common Plantain 60
Greater Mullein 61
Common Figwort 62
Yellow Pond-lily 64
Stamens developing before stigmas 66

PAGE
Wild Geranium; Cranesbill 66
Fire-weed; Great Willow-herb 67
Apple; Pear 68
Long-flowered Tobacco 69
Bouncing Bet 70
Night-flowering Catch-fly 71
Closed Gentian; Fringed Gentian 73
Bellflower 77
Mint Family 79
Blue-curl 80
Polygala sanguinea 81

CHAPTER IV

FLORAL MECHANISMS

Turtle-head 84
The Larger Blue Flag 86
Trumpet-creeper 88
Monkey-flower 90
Oswego Tea; Bee-balm 91
Garden Sage 92
Pale Spiked Lobelia 94
Cardinal Flower 95
Joe Pye Weed 96
Lion's-foot 98
Violets and Pansies 100
Nightshade 102
Downy False Foxglove 103
The Bean Family 104
Ground-nut 107
Tick Trefoil 108
Male Berry 109
Mountain Laurel 112
Barberry 114

PAGE

Poinsettia 116
Jewel-weed; Touch-me-not 117
Insect Prisons 118
Dutchman's Pipe 119
Milkweed 120
Spreading Dogbane 126

CHAPTER V

ORCHIDS

Pink Lady's Slipper; Moccasin Flower 133
Showy Lady's Slipper 135
Ram's-head Lady's Slipper 136
Small White Lady's Slipper 136
Large Yellow Lady's Slipper 137
Smaller Yellow Lady's Slipper 137
Showy Orchid 137
Round-leaved Orchis 140
The Habenarias 140
Smaller Purple Fringed Orchis 141
Large Round-leaved Orchis 144
Hooker's Orchis 144
Tall White Boy Orchis 145
Tall Leafy Green Orchis 145
Small Green Orchis; Tubercled Orchis 146
Ragged Fringed Orchis 147
Rattlesnake Plantain 147
Lady's Tresses 149
Rose Pogonia; Snake-mouth Pogonia 151
Whorled Pogonia 152
Arethusa 153
Coral Root 154
Lily-leaved Twayblades 154
Southern White Small Orchis 156
Grass Pink 157

CHAPTER VI

THE WIND AND THE FLOWERS

CHAPTER VII

SELF-FERTILISED FLOWERS

PAGE
Round-leaved Mallow 178
Spanish Bayonet 181

CHAPTER VIII

EFFORT AND ACCOMPLISHMENT

Thorns and Prickles 189
Burglar Insurance 192
Rain Shelters 193
Lures of Flowers 193
Insects and Their Favourite Colours 196
Pollen 198

CHAPTER IX

SEED SOWING

Pepper-box Seeds 205
Air Gliders 207
Airship Seeds 207
Tumble Weeds 209
Seeds Carried by Water 210
Seeds Dispersed by Birds and Animals 212
Edible Fruits and Seeds 214
Poisonous Fruits 214
Tramp Seeds 216
Catapult Seeds 219
Spider-flower 222

ILLUSTRATIONS

THE FLAME AZALEA (*In Colors*) . . . . . *Frontispiece*

FACING PAGE

THE GARDEN POOL 4

GENEALOGY OF JACK-IN-THE-PULPIT (*In Colors*) . . . 18

THE VALLISNERIA (*In Colors*) 26

WILD IRIS (*In Colors*) 80

THE LUPIN (*In Colors*) 104

THE BUTTERFLY WEED (*In Colors*) 126

NATIVE ORCHIDS (*In Colors*) 130

THE YUCCA FLOWER AND ITS MOTH 182

MEXICAN CACTUS 190

HONEY GUIDES AND RAIN SHELTERS (*In Colors*) . . . 192

THE MYSTERIES OF THE FLOWERS

THE MYSTERIES OF THE FLOWERS

CHAPTER I

INTRODUCTION

WHEN an imaginative child is born the Golden Age returns to fling its glamour over all earthly things. Fairies and all the little people of the mystic realm reawaken from their long sleep, infest once more the woods and dells, abide as of old in all the myriad flowers, and resume their sway over the insect world. Old legends become new truths in their telling, old magic renews its force and charm.

It is neither a fortunate nor a happy state to be an only and a lonely child. I remember many dreary autumn days when I used to

flatten my little nose against the window-pane and pray that some of my young comrades might come to play and enliven my loneliness. But my summer days were bright and happy ones spent in a lovely garden, where I grew to rejoice in the gay flowers and to find entertainment in watching the bees, the butterflies, and the humming-birds as they came and went; and I felt weird thrills when, at dusk, I caught a hazy glimpse of a spectral night-moth on his rounds.

Sniffing at the gay and sweetly scented lilies, I learned that flowers produced pollen, as well as honey, for I found that with it I had unwittingly painted my face an orange-yellow, and then I was told that the bees carried this pollen from where it grew to the place where it was required; that thus, and not otherwise, the seeds were made, and, without bees and pollen, there would be no flowers next years.

As I grew older I extended my walks to the fields and woods and included the wild-flowers in my affections. Then I tried to study about them, and to learn what others had learned and observed. But "Botany," as they called the study, was only a naming and classifying of my sylvan friends. It was as unsatisfying as a glance into a pastry-cook's window. It reminded me of a trip on one of the

sight-seeing cars where the conductor hurriedly announces through his megaphone the names of people who dwell in the residences along the way. I seemed to get not so much as a bowing acquaintance with the passing flowers; I learned nothing of their lives and habits, and gathered no gossip about their large circle of acquaintances among their insect guests.

Only when I came to our native orchids and began to rummage the bogs and the books for these rare treasures did I find a well-recognised affinity between the two great kingdoms. I had to travel far, and do a long novitiate, before the great mysteries of the flowers were revealed.

My experience, however, was but history repeated, for knowledge on the subject came very slowly: nearly two centuries were consumed by great naturalists in scientific research ere the great and simple laws were truly comprehended. The Golden Age was slow to pass away, and the old stories and legends about flowers and their slaves, the insects, were long in dying; and men seemed reluctant to question the doings of Nature about them, to investigate her conduct, and reduce her to a scientific formula.

From the days of Father Adam, and for untold centuries, men had sown their seeds, and gathered

their crops, never asking why their seeds were formed, nor how they germinated. They saw each flower bear pollen and nectar, and beheld the bees despoil them of their treasures. The farmer saw no connection between the seed and the pollen, between the bee and the flower.

They did not even know, though some very early philosophers seem to have suspected, that a seed is formed of two vegetable products, the yellow pollen, and the soft green bead or ovule, just as a crystal in chemistry is produced by the union of two chemical products, an acid and a base.

Considering the long years that went before, it seems quite recent that in 1632 an English naturalist, Nehemiah Grew, announced as his discovery that, in order that a seed may form, the pollen of a flower must touch its ovule. Without such contact the ovule would never develop into a seed, but would wither and come to nought. We know this truth so well now that it seems strange that there was ever much mystery about it; yet this theory of Grew was then so novel that scientists of his time were reluctant to accept it unreservedly.

In 1735, however, the great naturalist, Linnæus, reaffirmed the theory and published numerous conclusive proofs of his own; and thus some progress was made toward the unveiling of the mysteries of

THE GARDEN POOL

the flowers. We all, of course, are aware that the little ovule referred to is usually hidden in a receptacle resembling a vase with a long neck. This receptacle is known as the "pistil," its neck as the "style," and the receptive part above as the "stigma." The pollen we have seen growing in lilies, in tiny pods upon long slender supports. The support is called the "filament"; the pod, or pollen box, the "anther," and the two together are named the "stamen."

SELF-FERTILISATION
Theory of Grew, 1682

TRILLIUM
Stigma above Stamens

Above is given a section of a flower, showing the little ovule in its vase, and the pollen falling from its box. And here it will be seen that the pollen falls directly from the anthers upon the open stigma —as Nehemiah Grew explained in his theory, which was accepted and held for more than half a century in spite of the fact that there were certain cases to which

TULIP-TREE FLOWER
Anthers turned outward

it could not possibly apply. Thus, some flowers have pistils much longer than the stamens, so that the pollen cannot possibly fall *upward* onto the stigma, as in the sketch of a trillium flower. Also, there are flowers whose anthers open away from the centre of the flower and, shedding the pollen outward, stand as a barrier between it and the stigma, as in the flower of the tulip-tree. Yet, in spite of these objections, the theory of Grew was the best so far devised and was accepted in principle, for it explained the mystery of the pollen and its usefulness; but no satisfactory reason had yet been given for the existence of the colour, fragrance, and nectar, nor their usefulness in the economy of the life of the plant. The mystery hanging about them was all the more enshrouded because great numbers of flowers accomplished their mission though deprived of these endowments.

Another half-century rolled by ere new light was thrown on the question, when at length a German schoolmaster, Christian Conrad Sprengel, observed that the bees and insects seemed to prefer those flowers which possess colour, honey, and perfume, and neglect such as are devoid of them. In 1787 he published an admirable volume to prove that, in the former flowers, the insects transport the pollen from stamens to pistil, and in the latter this service is performed by the wind.

This theory of Sprengel's was built upon the discoveries of Grew and Linnæus, but went much farther to explain the "sweet reasonableness" of the flowers. It was a great advance in that it explained the purpose of these lures of the flowers which make them so much beloved by man and bee. The accompanying sketch, a section of a flower, shows us how Sprengel conceived the work of the bee was performed. We see a bumblebee in the act of seeking honey, and unintentionally rubbing the pollen off the anthers and bearing it to the stigma. Thus was I taught in our home-garden to understand the work of the bees, and I believe many people still understand it so.

INSECT FERTILISATION
Theory of Sprengel, 1787

Sprengel's theory was a new and startling one based upon countless observations and experiments —a very beautiful theory which explained the mysterious purpose of the lure of the flowers. It attracted much attention, aroused much discussion among savants, but was finally doomed to oblivion and its discoverer to disappointment and chagrin. He had penetrated only half the mystery and discerned only half the truth.

The theory explained the action of many insects and flowers, but yet many cases were found to

which it obviously could not apply. Instances were pointed out where flowers bore stamens and no pistils, or pistils and no stamens. Others proved to ripen and shed their pollen before their pistils were ripe to receive it. Others had their pollen concealed in little traps which closed when the

CROSS-FERTILISATION
Theory of Darwin, 1859

bee entered, and opened only when he withdrew and dusted him with a golden shower when too late for him to carry it to the pistil. In the sketch are shown three flowers embodying the objections to the theory of Sprengel.

So the half-truth was rejected as wholly disproved, the theory of Sprengel was discredited, and the mysteries of the flowers remained obscure for nearly another hundred years.

Grew and Sprengel had partly unwrapped the

veils enshrouding the truth, but Darwin, in 1859, lifted them completely away. In a book that year published he showed conclusively, and beyond any doubt, that not only did the bees and insects carry the pollen of flowers, but that they carried it from the anthers of one flower to the pistil of another; that this plan gave vigour and adaptability to the species, and that many flowers possessed ingenious mechanisms to protect their stigmas from the touch of their own pollen, and to insure the transportation of it to another flower.

This Darwin called "cross-fertilisation," and he was able to prove that this great scheme and purpose pervaded the whole realm of the Floral Kingdom. This was the great Mystery of the Flowers which Nature had at last revealed.

Since Darwin's theory of cross-fertilisation was announced many students have investigated, with powerful microscopes, the action of the pollen after it reaches the stigma of a flower, and have restricted to this action the term "fertilisation"; the bringing of the pollen and placing it upon the stigma they call "pollination." But this latter is an awkward and unfamiliar word, and, as none can deny that cross-pollination ultimately brings about cross-fertilisation, in the earlier part of our studies we will stick to the older and more familiar term, using it in

a sense to include both pollination and fertilisation.

The mechanism of the flowers as explained by Darwin is shown by the sketch, where bees are visiting several flowers in succession and carrying the pollen from the stamens of one to the pistil of the next.

CRANESBILL

For my own part I never regretted the changed point of view, for I found just as much food for my imagination in studying the flowers and the insects as they are, eager, living things, striving as we strive, flourishing in spite of difficulties, and attaining to the beauty of perfect living. And for me the charm of some old legend concerning a flower was but enhanced when, in addition to it, I was able to unravel some secret of its inner life, hidden in the fragrant recesses of its heart.

Instead of a fairy world, the realm of the flowers may be said rather to resemble a busy modern town, full of merchants, vying with one another in the sale of their wares, and of buyers lured and tempted to traffic,

The simile is not merely superficial, and we will trace the resemblance deeper. The flowers are the shop-keepers who deal in nectar and in pollen, and these they advertise in gaudy, flaming placards about their entrances—blotches and streaks of vivid colour—honey guides, we call them—which are veritable posters to attract the eye from afar. Then, to greet the coming purchaser, they put forth easy landing-stages, for their guests are living aeroplanes who must furl their wings before entering. Then, too, the merchandise must be kept away from dew and rain, so the flowers set up ingenious rain shelters of varied form. Lastly, there must be protection against unwelcome insects, veritable shop-lifters, and for these the flowers provide bristles, traps, and devices which make theft almost out of the question. The flowers are so astute in their competition for trade, so cunning in their ways of winning it, so like clever tradesmen, in fact, that we find much of human interest in watching their trade competition, and thus discover a new bond of sympathy between their little lives and ours.

We who live close to nature and love the plants of the garden and the wild wood, discover that they are living beings like ourselves, whose lives are shaped by the same great laws.

They first strive to live their own lives by seeking

food and drink, and their "place in the sun." Thus they fight the struggle for existence.

Secondly, they proceed to bear flowers and produce seeds in great quantity, in order that their family may continue.

Thirdly, they make a distinct effort to strengthen and improve their offspring, so that their race may survive. This we might call eugenics, and experiments show that cross-fertilisation is a very important factor to that end. If the individuals die there will be no race, but if the race deteriorates there will ultimately be no more individuals.

Granting, then, that Darwin was correct in asserting that there exists a system prevalent among the flowers, which he called cross-fertilisation, let us examine as many flowers as we can and discover:

First, what benefit accrues to the race of plants by this system; second, by what various means is the pollen transferred from flower to flower; and, third, are all flowers always cross-fertilised, or are some of them, sometimes, self-fertilised, and, if so, by what means.

THE UTILITY OF CROSS-FERTILISATION

Plants are not restricted to a well-made garden, in a mild climate, generously watered and with rich soil. They grow and flourish in every zone from

the torrid to the polar, in every soil from rich river-beds to sandy deserts, and under varying degrees of nurture from oozy swamps to arid deserts.

Plants have to fit themselves to these various locations, and to the differences of season, or else they must die. To survive they must be able constantly to adjust themselves to changing conditions. Now it has been shown by thousands of experiments that cross-fertilisation produces very numerous and thrifty seedlings, part of which may so differ from either parent that they will survive where either parent might not. Cross-fertilisation so improves the vigour and the adaptability of the young plants that they may spread into new districts and climates, surviving and increasing in numbers in spite of the great struggle they must wage.

Cross-fertilisation, then, is of vital and overwhelming importance, which the plants seem to understand. Consequently great pains and ingenuity are expended to accomplish this desideratum.

There are various methods for procuring cross-fertilisation, which may be grouped as follows:

Staminate and pistillate flowers (dicœcious and monœcious).

Prepotence of foreign pollen over that of home production.

Position of stamen and pistil, including dimorphic and trimorphic flowers.

Stamens and pistils developing at different times, called "dichogamous."

Various mechanical devices which aid cross-fertilisation and preclude self-fertilisation.

These methods we will now take up in the order stated.

CHAPTER II

PISTILLATE FLOWERS AND STAMINATE FLOWERS

IT is self-evident that flowers wholly pistillate or wholly staminate run no risk of self-fertilisation; and nature adopted this simple plan in the case of most of our trees, such as pines, beeches, and birches, whose pollen is carried by the wind, and in many plants, as the clematis, Virginia strawberry, the flowering spurge, and Jack-in-the-Pulpit, whose pollen is transported by insects.

Trees or plants which bear the pistillate or the staminate flowers separately are said to have the "dicœcious habit," while those which bear both kinds of flowers on one plant follow the "monœcious."

WILLOW CATKINS

DIŒCIOUS FLOWERS

The flowers of the willow, spoken of as catkins or pussy-willows, which are among the first growing things to announce the impulse of spring, are discovered to consist in the one case of merely two stamens and in the other of a pistil, springing from the axil of a small, furry bract which has shielded them from the winter cold. They lure the bee for the same reason that they attract us, not because of any charm of colour, but because there are no other flowers to compete with them. Some willows are monœcious.

Asparagus

When the garden asparagus has gone to seed it will be noted that some plants are full of pretty, red berries, while others are completely sterile. This is due to the fact that some bear pistillate and others staminate flowers. Very inconspicuous they are, owing to their greenish colour and small size, but the staminate flower is the

ASPARAGUS

larger of the two, to attract the insect to it first, in order to give him a charge of pollen. It resembles a little lily, and bears at its centre an undeveloped pistil. The pistillate flower opens less widely, and therefore resembles a small tulip, with two cleft pistils and the very large ovary within. At the base of this we find six minute and unformed stamens; so we see that each flower is trying to become a perfect flower; that the asparagus is still in a state of development and may in course of time abandon the diœcious habit and succeed in producing flowers with both pistils and stamens; or it may now be degenerating and losing the power to produce perfect flowers.

Devil's Bit, or Blazing Star (*Chamælirium luteum*)

DEVIL'S BIT

A somewhat rare flower, growing in moist soil and blooming in May and June. The staminate flowers—with six stamens and six narrow, cream-white petals—grow in a long, gracefully bending spike. The pistillate flowers—of a greenish white, consisting of an ovary with its pistils three-parted, and six narrow petals—are crowded close in a short, stiff spike, easily distinguished afar off from its companion flower. The two kinds of plants are

often widely separated from each other, but the unerring instinct of their insect affinity is a sure guide to bring about cross-fertilisation. These flowers are pleasantly fragrant, and thus attract many small beetles and flies, which become entangled in the maze of the stem and the petals of the flowery plume. On one specimen were discovered a brown creature resembling a small scorpion, several ants, one very small beetle and six "snapping bugs." Since these latter were the most numerous and the best on the wing, I presume that these are the ones that do the most of the work in carrying the pollen.

I kept a few of these insects fasting over night, and when they were given fresh flowers in the morning they immediately fell ravenously upon the pollen and devoured some, while dusting their heads and antennæ with a goodly supply.

I am unable to discover, or even to conjecture, the reason for giving to this dainty flower such a title as it bears. To the botanist it is always an interesting "find."

JACK-IN-THE-PULPIT—*Arisæma triphyllum*
April-July

This is a native of America resembling in appearance the plant known in England under the name

GENEALOGY OF JACK-IN-THE-PULPIT

of "Lords and Ladies" (*Arum maculatum*). The flowers of the two countries are, however, not identical, either in form or in their modes of securing cross-fertilisation, and the distinction should be fully explained as illustrating a phase in the development of plant life.

The Lords and Ladies bears upon the spadix a group of staminate flowers, closely crowded together, and below them a similar group of pistillate flowers: therefore the plant should be classed as monœcious. Jack-in-the-Pulpit (and we might say "Jill-in-the-Pulpit"!) bears either stamens or pistils; hence it is diœcious.

Glancing at the plate showing the genealogy of Jack-in-the-Pulpit and comparing the three sectional drawings, we see in Jack-in-the-Pulpit that the hood, or spathe, tapers uniformly and droops far out over the opening, as the rain shelter. Small purplish stamens cluster at the base of the spadix in the one, and beady little pistils upon that of the other flower. Notice that there is a considerable space at the base of the staminate flower where pollen accumulates, and where the insects wallow in it. But in the other flower the pistils nearly fill this space, so that insects, bringing pollen, must necessarily rub against the stigmas. Squeezing through here in search of nectar, they are often

caught and held prisoners to the end of their lives. I have torn open many flowers and have found dead insects in the pistil-bearing flowers only; these were mostly specimens of the Fungus-Fly, or *Mycetophilia,* shown greatly enlarged in the drawing.

Now, turning to the section of a flower of the Lords and Ladies, we see that the spathe swells out at the base and contracts again, forming a small room around the base of the spadix, thence rising into a pointed hood much more open than that of Jack, in spite of the moister climate of England. Low upon the spadix is a group of pistils; next above comes another of stamens; and above these, again, a ring of stiff hairs, pointing outward and downward, at the narrow part of the hood, so as to form a trap to admit insects from outside but to keep them prisoners within. Also, these hairs prevent the insect from crawling down the spadix, but guide him to enter by the outer wall, so that he cannot reach the staminate flowers first, but must pass down to the bottom, crawl up over the stigmas, leaving on them any pollen he has brought, and then seek fresh pollen from the anthers. For a time, however, he will search in vain, for the stamens do not ripen till several days after the pistils, and the unwilling guest must remain a prisoner, com-

fortably housed and well-fed, till the pollen is ready for delivery, at which time the hairs wither and fall, the prison bars vanish, and the insect may climb out over the stamens and escape with some pollen; only to repeat his house-breaking, be caught and serve another term.

Thus we see that the habits and doings of the American and the English Arum are very different, and we are led to wonder which of the two is the older type. We will find a clue to the answer in closer scrutiny of Jack-in-the-Pulpit; for among the pistillate flowers we will often find one or two little stamens popping out in unexpected places upon the spadix and trying vainly to furnish pollen for all the clustered pistils. These unexpected and useless little stamens show us that Jack-in-the-Pulpit has an hereditary tendency to produce perfect flowers; that he harks back to early ancestors like the Lords and Ladies of the Old Country, and still, once in a while, reverts to his primitive ways.

Jack-in-the-Pulpit is a degraded lily which has lost its petals, its colour, and finally, in America, has gone back to the diœcious habit; and it so happens that all the intermediate stages of its descent may be followed in living specimens. The proud ancestor of the line, the lily, bears a showy, six-

parted corolla, enclosing six stamens and a pistil. Now, let us examine a spike of the sweet flag (*Acorus calamus*) with a powerful glass, and we shall discover a myriad of minute lilies packed close together. Each floret has the complete structure of a lily, though suffering from the close proximity of its neighbours. The petals have been reduced to mere scales, each one protecting a stamen. The sketch represents a floret highly magnified. The reason for this crowding together of the little lily flowers into a close spadix is easy to discover. The plants grow near the water and have to depend upon the minute gnats, beetles and other tiny insects which swarm about the pools, and which are indifferent to an appeal to their colour sense. And flowers small enough to receive such midgets must get closely together, and send forth their lure in union—they must do team work if they are to succeed at all; hence the crowded spadix, with its multitude of florets, over which the visitors may wander at will.

Now examine the spadix of a water arum (*Calla palustris*) and you will discover that the florets have lost their petals, and not all of them are perfect flowers. The lower ones are both staminate and pistillate, but the upper ones often are staminate only.

The white calla, or *Richardia,* has gone another step, as we shall find all the upper portion of its spathe to be covered with stamens, while below are clustered numerous ovaries accompanied by an uncertain number of stamens.

The English Lords and Ladies shows the complete separation of stamens and pistils, the former growing upon the middle portion of the spadix and the latter below; in addition, the fringe of hair has developed to entrap the insects, and the upper tip of the spadix has become a smooth perch for them to alight upon.

The change from this state to that of the Jack-in-the-Pulpit seems great and sudden. To produce stamens and pistils in the same plant, and then to change the plan and ever after grow stamens on one plant and pistils on another looks revolutionary at the first glance. But consider that you have only to suppress the stamens on a plant of the Lords and Ladies, and there you have a pistil-bearing plant, or the reverse. Moreover, the stamens do not forever stay suppressed and are occasionally cropping out again to show us that Jack-in-the-Pulpit has not so very long followed the dicœcious habit.*

* For fuller description of the ancestry of Jack-in-the-Pulpit, the reader is referred to *Flowers and Their Pedigree,* by Grant Allen.

The grape, also, seems to be passing through a similar transition, and to be taking its time about it. In "Bible Times"—some thousands of years ago—the vine-dressers had much to say about the "fruitful" and the "unfruitful" vine: a perversity that they could only deplore but not explain. To-day the microscope shows us that some vines bear perfect flowers and consequently fruit, while others retain a semi-diœcious trick of putting forth staminate flowers and are consequently sterile of fruit. I discovered two vines of the latter sort in our vicinity—a puzzle to the natives—which each year put forth quantities of blossoms but never bore a grape, even in a "grape year." The adjoining sketch will show the difference between the sterile and the fertile blossoms.

GRAPE FLOWERS

VIRGIN'S BOWER—*Clematis virginiana*
July-August

A lovely climbing vine, profusely covered with bunches of white, fragrant flowers which, after

they have faded, seem to return again in October as fluffy, filmy things, ghosts of the dead flowers of summer. Staminate and pistillate flowers grow on separate plants, but the latter have the curious habit of producing sterile stamens along with the pistils, which may indicate a tendency or an aspiration on the part of the plant ultimately to produce perfect flowers. The pollen is carried by bees, bee-flies (*Bombilius*), and the bright-coloured flies of the *Syrphidæ;* and at night their white blooms and heavy perfume attract numberless small white moths.

Tall Meadow-rue—*Thalictrum polygamum*
July-August

The tall meadow-rue, shown at the head of this chapter, is a dignified and decorative plant of the same family, the Crowfoot, with flowers somewhat similar. Like the clematis, the flowers of the tall meadow-rue are diœcious, and the pistillate blossoms also sometimes bear stamens; but in this case they are fertile, pollen-bearing stamens, making such flowers perfect. This shows that the rue is just a little higher in the scale of development than the clematis, and a little nearer to the ideal flowering plant.

GOAT'S-BEARD—*Aruncus sylvester*
May-July

This is a plant flourishing in New York and southward. Its flowers, minute and yellowish-white, are crowded upon small spikes, and these latter are clustered together into a large, compound spike. This is classified as belonging to the Rose family; but it is an exception to the general rule of that family in that the staminate flowers grow on one plant and the pistillate on another.

EEL GRASS; TAPE GRASS—*Vallisneria spiralis*
August

Though there are many staminate and pistillate flowers growing on separate plants, it is quite unique to find any of the former which break loose from their stems, skip over and snuggle beside the latter and offer a gift of pollen. Yet this extraordinary conduct is just what is to be found in the *Vallisneria.* Being a water-plant, the staminate flower swims to its mate, and thus might be called the Leander of the Flowery Kingdom.

VALLISNERIA

It is very common in lakes and rivers. Rooted firmly to the bottom, its long, narrow leaves swing

THE VALLISNERIA

in the current and often entangle our oars. The pistillate flower-buds rise to the surface on exceedingly long and slender stalks, varying in length according to the depth of water, and are found singly in a tubular spathe. The calyx is three-parted, with a long tube, and there are three stigmas, each with two tubes. The flower is shown in the accompanying figure. The staminate flowers grow crowded close together in an ovate, three-valved spathe, mounted upon a very short stalk. At the proper time these flowers are set free and break loose from their parent stem. Since they are lighter than the water, they rise to the surface and are carried by the shifting currents to the vicinity of the pistillate flowers, and shed their pollen, some of which is sure to reach the awaiting stigmas. Now another curious movement occurs. As soon as the pistillate flowers have become fertilised their long stems curl into spirals, drawing them down into the depths of the water where they perfect and shed their seeds.

The foregoing list of diœcious flowers is very small and incomplete, but will suffice to show that the habit is alike common to stately trees, aspiring vines, and humble herbs, and the descriptions and diagrams will prove that the crude and simple

flowers are yet marked with strong character, and while possessing little beauty are yet not devoid of ingenuity in mechanism.

We will now proceed to examine as many as possible of the other class.

MONŒCIOUS FLOWERS

The Gourd Family

One of my childish delights in the garden was to plant, each year, a few gourd seeds and watch the vines climb rapidly, and wonder what strange variety and quaint form of fruit they would give me; and thus I discovered that certain flowers bore no fruit at all, while others, with a very evident "set" below the bud, were sure to develop into gourds. Thus I learned to know the "sterile" from the "fertile" blossoms, or the pollen bearers from the seed bearers. By the same token I learned that the gourd family was very susceptible of cross-fertilisation, even between different varieties, for by planting the seeds from a favourite little bottle-gourd, of dainty form and colour, the following

SQUASH-BLOSSOM

year I grew a strange and heterogeneous progeny like oranges, green clubs, flat squashes, and various things—all the visible signs of the work of the busy bee.

This lesson has long been learned by the seedsmen to such good effect that they are obliged to resort to severe methods to keep pure their strains of seed of squashes, cucumbers, and melons. Some seedsmen enclose with fine wire screens the whole patch of a single variety. Others grow immense fields of one kind in one locality, and, as far as a bee can fly in every direction, they pledge their farmer neighbours to grow no other squashy thing, bribing them with some seeds of the good variety to be preserved. In the Rocky Ford district, famous for its delicious muskmelons, it is humorously said that a farmer would be lynched if he were to plant a single squash-vine. In England, where summers are short and cold, muskmelons are necessarily grown in greenhouses, with a hive of bees to carry the pollen from the staminate to the pistillate flowers, without which no fruit would be produced.

Wild Balsam-apple—*Echinocystis lobata*

A very charming and decorative vine, growing in great profusion along our roadsides, bearing,

in July pretty clusters of greenish white blossoms, and, in October, strange seed-vessels like transparent chestnut burrs. No matter how the vine climbs and twists and disports itself, the flower spires are seen to stand vertically, with one, or at most a very few, hanging down below the vine, at the point whence the vertical flower-stalk springs. The upper and numerous flowers are pollen bearers, the lower ones seed-makers. We can understand the logic of the arrangement, knowing the habits of the bee. As he works from below, upward, he alights first upon the pistillate flowers, then climbs the floral spire, gathering pollen as he goes, to take it down to the pistillate flowers on the next group—and so on with drops and climbs till he has disarranged the pollen along the whole garland of the vine.

WILD BALSAM-APPLE

Arrowhead—*Sagittaria*

This decorative flower which beautifies the margins of our ponds with its white flowers from July to September, presents twelve distinct species.

Though some of these exhibit a dicœcious habit, as a whole the Arrowheads are moncœcious. Their flowers grow in groups of three around a tall, central stem. The lower ones, on very short pedicles, are the first to bloom, and are pistillate. Above the first or second group the flowers become staminate and grow on longer pedicles.

Schuyler Matthews says: "The pollen of the *Sagittaria* is distributed by a variety of agents, not least of which are the insects which frequent wet places, among them the glossy-winged dragonfly."

Comparing for a moment the two habits of plants or trees, the dicœcious with the moncœcious, it seems to the writer that the former is less an advanced stage of development than the latter. Surely, staminate and pistillate flowers growing on separate plants are farther away from the perfect flower than are those which grow on the same plant.

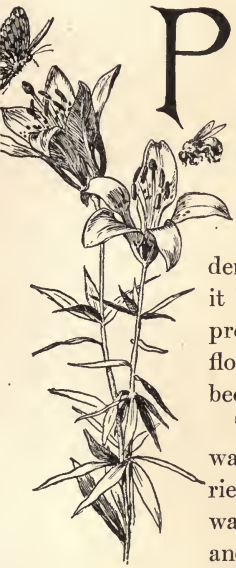
Though both dicœcious and moncœcious flowers form seeds in plenty by a plan insuring cross-fertilisation, they seem not fully to have satisfied the desires of Dame Nature, and her next experiment consisted in producing both pistils and stamens in the same blossom, as if to see what would happen under such conditions.

I believe that pistils and stamens at first grew

far apart; then, through centuries of slow progress, they gradually approached one another, and at length became close neighbours, within the fragile stockade of the corolla of a perfect flower. From that time forth, I surmise that the flowers evolved ever more highly specialised forms, habits and mechanisms, till the orchid came into being, the latest and most complete expression of the floral efforts.

CHAPTER III

PERFECT FLOWERS



PLANTS bearing perfect flowers are far more numerous than those bearing pistillate and staminate ones. We must, therefore, conclude that it is a much better arrangement to have stamens and pistils grow in the same blossom. The most evident advantage is that of economy: it brings about great saving of the precious pollen, there are no sterile flowers, and the time of the busy bee is not wasted.

There was a time when wind and water were the great "common carriers" of the pollen, and the work was so well done that plants grew and throve. But better means of transport came into existence. In-

sects of many sorts arrived on the scene, as we know from the fossil remains of them preserved in the rock-formations, and simultaneously with them appeared "real" flowers. Then began the business of insect-fertilisation, with all its invitations and visits, its ceremonies and subterfuges. The imperfect flowers of earlier times were not wholly superseded, but vast numbers of perfect flowers were developed, combining stamens and stigma in one showy corolla, made more alluring by its colour, nectar and fragrance.

When I speak to you of a "flower" there probably flashes into your mind the image, not of a pine-cone, nor of a cat-tail, though these are flowers, but that of a rose, a lily, or a poppy—some bright, regular flower, with the pistil as a centre, surrounded by stamens and enclosed in a cup or fringe of petals symmetrically disposed. They are wide open to every comer, and attract hosts of insects.

WINDFLOWER; WOOD-ANEMONE—*Anemone quinquefolia*
April-June

The beautiful little star of the early spring gives welcome and holds open house to the bees and bee-like flies of the genus *Bombilius*.

White Water-lily—*Castalia odorata*
June-Sept.

The shining petals of the white water-lily part in the early morning, only to close again in the afternoon. They offer no nectar, but a plentiful supply of pollen, which is eagerly sought and easily obtained by bees and beetles.

Common St.-John's-wort—*Hypericum perforatum*
Marsh St.-John's-wort—*Hypericum virginicum*
July-Sept.

The full clusters of golden-yellow blossoms of the one species, and the smaller clusters of a pinkish flesh-colour of the other, have no nectar but produce plenty of pollen on their numerous stamens, and serve it up freely to the pollen-eating flies and beetles.

Common Mallow—*Malva rotundifolia*
June-Oct.

An exceedingly common weed, with whitish flowers, its five petals veined with magenta. In America it has become naturalised from Europe, and flourishes because it pleases and satisfies a host of the native insects, such as the honey-bee, *Bombus agrarum* and *Halictus morio.*

HARDHACK; STEEPLE-BUSH—*Spiræa tomentosa*
July-Sept.

The spires are composed of myriads of minute, deep-pink blossoms, which bloom from the apex *downward,* offering their pollen freely and without restriction to pollen-collecting bees.

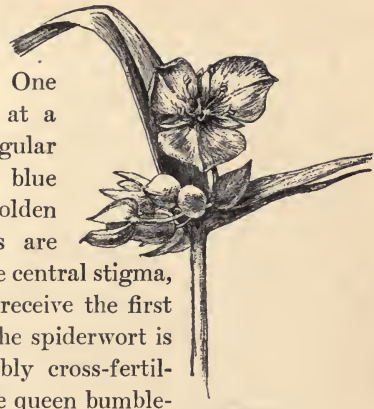
FLOWERING DOGWOOD—*Cornus florida*
April-June

We are prone to speak of the *white* flowers of the dogwood, mistaking the four conspicuous white bracts for petals, which serve as nectar guides. The true flowers are minute and clustered close together. When magnified they appear like small lilies, as in the sketch, each with four greenish waxy petals, curling far back, and four stamens standing erect and high above the stigma. Its sweets are easily accessible to bees, flies, and butterflies.

DOGWOOD

THE SPIDERWORT—*Tradescantia virginiana*

A plant, fairly rare in New England, which adds to the charm of its beautiful blue colour an unusual form. At the top of the stem, nestling



SPIDERWORT

in the axis of three narrow leaves, grows a tassel of flower buds. One or two of these open at a time, disclosing a triangular blossom of heavenly blue petals and a cluster of golden stamens. The anthers are widely removed from the central stigma, which is thus likely to receive the first touch of the visitor. The spiderwort is said to be unquestionably cross-fertilised by the earlier of the queen bumble-bees, *Bombus Pennsylvanicus* and *Bombus Separatus*. In the centre of this flower will be discovered a tuft of hairy growth. Each of the six filaments is bearded, and the whole cluster forms this little tuft, which may have come into existence as a barrier to prevent crawling insects, who have touched the anthers, from climbing the style to the stigma and self-fertilising the flower.

HEDGE BINDWEED—*Convolvulus sepium*
June-August

This is the bride among the morning-glories, for its trumpet, pistil and pollen are all white. The

anthers are creamy-yellow, and cluster close against the long style, shedding their pollen outward. They invite the nocturnal insects, as is shown both by the lack of colour and their habit of closing at the kiss of the sun. The long pistil is sure to receive whatever pollen its visitor may bring. It is visited by the Sphynx moths.

We have described enough of these regular, wide-open flowers. These, and many more like them, might easily receive their own pollen on their stigmas, a thing which doubtless often occurs. Must we, then, believe that these flowers do not require cross-fertilisation? Can they flourish and survive in defiance of the great law which requires occasional mixing of hereditary strains?

CONVOLVULUS

They have no structural nor mechanical contrivances, as some other flowers have, but there is a "saving clause" in the law of heredity which pro-

tects them from enfeeblement and extermination. These simple, accessible flowers do not depend upon cunning mechanisms, but upon a principle which rules the flower-world: namely, that the pollen of a flower is not as effective on its own stigma as the pollen from another flower of the same plant, while pollen from a different plant of the same kind is the most effective of all. This prepotence of pollen from afar will be more fully dealt with later.

The flowers under consideration most likely receive some of their pollen on their own stigmas, but they seem to count upon the luck found in numbers. The more numerous the insect visitors, the greater their chance to bring foreign pollen which will prevail in fertilising power over that of home production, and the resulting seedlings will have increase of vigour and superior adaptability, the better to fit them for ever-changing conditions, that they may win in the perpetual struggle for life.

Apparently the wide-open flowers succeeded all too well in attracting the insects. The latter, being copiously fed, became sleek and fat, propagated enormously, and charged in ever-increasing hordes upon the flowers. Uninvited and undesirable guests came unbidden to the free banquet, and

went away without paying their toll. Something had to be done to restrict the Bacchanalian revelry and compel the insects to do the service expected of them: namely, to fetch and carry pollen among the flowers.

A slight change in the relative lengths and positions of the stamens and pistils would certainly help matters, and accordingly many flowers adopt, and survive by, such improvements. One such aid is to be found in the flower which turns its anthers away from the stigma, and sheds its pollen *outward*. Another will be seen in the flower whose style is very long, bearing its stigma far in advance of the anthers, thus coming out of doors, as it were, to welcome the guest before he has reached the threshold.

MARSH MARIGOLD—*Caltha palustris*
April-May

MARSH MARIGOLD

This little plant, which enlivens with its colour the borders of our ponds and streams in early spring, bears wide-open flowers with plenty of nectar, and numerous pistils and stamens ripening simultaneously. They attract the beautiful yellow flies of the *Syrphidæ* family, who do much

of the work of fertilisation. As in the tulip, the anthers open outward, the outermost ring being the first to ripen; thus the stigmas are somewhat protected and cross-fertilisation is slightly favoured.

FIELD MUSTARD—*Brassica arvensis*
May-Sept.

When this common yellow flower unfolds, the anthers turn away from the stigma, and the bee thrusts his head between them and the petals in search of the nectar secreted by glands at the bases of the stamens. As the flower grows older and withers the anthers turn their pollen-covered side upward, and finally their tips curve toward the stigma, so as to effect fertilisation if that has not already been accomplished with pollen from elsewhere.

It is visited by bees, bee-flies and beetles.

COMMON ELDER—*Sambucus canadensis*
June-July

ELDER

These little flowers, individually so inconspicuous, become showy in their close, flat groups. The whole corymb forms a landing stage for insects, who crawl over it from floret to floret. The stamens spread far away from the

pistil, and although self-fertilisation might easily be affected by insect visitors, cross-fertilisation is far more likely to take place, for when the insect settles first upon the stigma cross-fertilisation is a certainty, and if he alights upon a petal cross-fertilisation is still probable, owing to the spreading of the anthers. The elder is visited mostly by honey-bees who come in search of pollen, as their blossoms have little nectar to offer as a lure.

WATER PLANTAIN—*Alisma plantago-aquatica*
July-Sept.

Though the flowers of this plant grow in a much more open cluster than the foregoing, the florets bear a resemblance to those of the elder in having the short stigma and wide-spreading stamens. They are visited by the bee-like drone flies (*Syrphidæ*), to whom they offer both pollen and nectar.

YELLOW STAR GRASS—*Hypoxis hirsuta*
April-July

YELLOW STAR GRASS

A charming little golden star flower whose six stamens spread as wide as they can, resting close against the petals. They attract the smaller bees (*Halictus*) and the butterflies (*Brenthis Bel-*

lona), known by the familiar name of meadow fritillary—probably because their tawny wings are spotted with deeper brown, much as are the fritillary flowers.

VIRGINIA LUNGWORT—*Mertensia virginica*

In the Virginia lungwort the stamens are spread as far from the pistil as the tubular shape of the flower will permit.

FORGET-ME-NOT—*Myosotis palustris*

The stamens in this friendly little flower grow against the walls of the flower tube, being suspended from the ring, or connected at the junction of tubes and petals. When a bee visits the flower he rubs one side of his tongue against the stigma and the other side against an anther—a very neat little scheme which works all the more surely because the bee makes but one thrust into the flower.

FORGET-ME-NOT

We have given sufficient examples of flowers shedding pollen as far as they can from the stigma, and now we will examine some which

send their stigmas as far as possible away from the pollen.

If a pistil is much longer than the stamens, it is likely to receive the first touch of an approaching insect, and will thus brush off and hold any pollen that he is bringing from another flower. We know that flowers are wise in their generation, and ready to seize upon any invention which will help them in their struggle, so many of them have sagaciously adopted the above-mentioned scheme.

Pistils longer than the Stamens

PINK AZALEA—*Rhododendron nudiflorum*
April-May

Let us go to the edge of some wood and watch the flowers of the pink azalea, with their long styles and protruding stigmas, and study the action of the moths and butterflies — guests whose long, prehensile beaks are just fitted to reach deep down into the trumpet and suck the honey, and whose bodies are just long enough to receive on the under side of the abdomen a touch

AZALEA AND MOTH

of pollen, and perfectly adapted to the task of carrying it to the stigmas of other flowers.

Watch and you will be charmed to see flowers and butterflies working in perfect unison, with a singular rhythm, like the parts of a finely adjusted mechanism, or like some clever musician adroitly manipulating the keys of his instrument. The yellow tiger swallow-tail butterfly, the clear-wing or Sphynx moth, and the humming-bird are frequent visitors to the azalea. The pink azalea occurs in Japan, and according to a print from there it seems identical to the pink azalea of America. The flame azalea, one of our most gorgeous flowers, was discovered in the Alleghanies, and flourishes under cultivation. It has little or no fragrance, but its colour and nectar attract especially the tiger swallow-tail butterfly. The fact should be noted that insects often show a preference for flowers whose colour resembles their own, a circumstance which later will be more fully discussed.

White or Clammy Azalea—*Rhododendron viscosum*

This blooms in June and July and sends forth a rich and heavy fragrance, doubtless to attract the night-moths. Outside the corolla tubes it has a sticky, hairy coating to keep away creeping insects.

TRUMPET HONEYSUCKLE—*Lonicera caprifolium*
May-Oct.

This flower is a convenient one to observe and study, because it is found so near our homes, often clustering about our porches and, of a summer night, sending its heavy and delicious perfume into our windows, recalling romantic evenings and distant lands. Then, too, its visitors, the night-moths, come in a stealthy, spectral fashion, flitting and fleeing on filmy wings impalpable as a fairy-tale. Yet the honeysuckle is just as earnest in its nature and just as ingenious in its efforts to succeed.

HONEYSUCKLE

Its stigma advances well beyond the group of anthers, and all are nicely proportioned to brush against the downy body of the hawk-moth. Its trumpet is exactly proportioned in length and diameter to fit the moth's tongue, and the fragrance and nectar well up in an increasing tide when twilight falls and the guests are due to arrive. When bees try in vain to sip at the honeysuckle I am reminded of the fable of the Fox invited to dine with the Stork and unable to drink from the tall vase, which offered no difficulty to his long-billed host.

GREAT LAUREL—*Rhododendron maximum*

RHODODENDRONS

Originally from the Alleghanies, though now found extensively under cultivation, the Great Laurel presents the same scheme of procuring cross-fertilisation as the flowers already mentioned, with this peculiarity: the anthers resemble two little meal-bags with open mouths pointing upward, ready to dust the under side of the visitor with pollen the moment he sets them vibrating on their long spring-like filaments. The microscope discloses that the pollen-grains are bound together in long, furry chains.

MOUNTAIN LAUREL

MOUNTAIN LAUREL—*Kalmia latifolia*

This has similar anthers, with, however, a much more complex mechanism, to be later described. Its long protruding pistil receives the first touch of an approaching moth before the stamens are disarranged.

HORSE-CHESTNUT—*Æsculus hippocastanum*

The handsome spires of horse-chestnut bloom are found to consist of orchid-like blossoms, fluted and showily marked with colour, pink on some and yellow on a neighbour, their stamens and pistils curving forward and upward, with the latter well in advance. But all are not perfect flowers: at least two-thirds on each spire bear pollen yet have sterile pistils.

SHINLEAF—*Pyrola elliptica*
July

The shinleaf has similar habits, save that it turns its face down toward the ground and, therefore, protrudes its long, curving pistil for a landing-stage. Here insects may alight and, first touching the stigma, climb up into the corolla for nectar and more pollen. Roofed by the overhanging petals are ten pollen-bags, packed closely together and ready, at a touch, to discharge their contents upon the visitor who ventures to climb up into the flower. The great abundance of these flowers and their sweet fragrance attract successfully the bee-like flies (*Syrphidæ*)

PYROLA

and the bees of the genus *Halictus* to good effect, as we shall discover later in the season by the great numbers of seed-vessels which ripen.

WAKE-ROBIN; BIRTHROOT—*Trillium erectum*
April-June

The common name for this plant is not strictly exact, for the robins come first to awake the Trillium; yet the flower appears among the advance-guard to assure us that spring has come. Even the dull, brownish purple-red is welcome at this season; but I cannot say as much for its disagreeable, fetid odour. Yet both colour and odour please the green flesh-flies (*Lucilia carniciana*), who are the best pollen porters for the Trillium. (See the sketch on page 5.)

In flowers like this, the insects make a dash for the centre and, if they hit the mark, land upon the stigma. Leaving what pollen they bring, they then climb down upon the corolla, and, obtaining nectar and more pollen, fly away without again touching the stigma. They may, however, miss the centre of the flower altogether, and rest upon the petals only, thus doing neither good nor harm.

BLUE-EYED GRASS

BLUE-EYED GRASS—*Sisyrinchium angustifolium*
May-June

The pistil of this flower stands well above the corolla. Below it are grouped three stamens. What seems the corolla is a cup, or six-pointed star, formed by three petals and three sepals of lovely violet-blue. The flower is cross-fertilised by the bees and the bee-like flies (*Syrphidæ*) who, on arriving with pollen, first touch the advancing stigma, which is three-parted and sensitive only on its upper surface. On retreating, the insects may brush against the under and insensitive surface of the stigma only.

SWAMP ROSE-MALLOW—*Hibiscus moscheutos*
August-Sept.

SWAMP ROSE-MALLOW
Stamens and Stigmas

The swamp rose-mallow shows us another fine example of this mode of making sure that the stigmas shall receive the first contact of an approaching insect. They consist of a group of five adhesive discs, far in advance of the many pollen-bearing stamens, growing like a furry muff around the central style.

PITCHER-PLANT—*Sarracenia purpurea*
May-June

A singularly interesting variation of this scheme of protruding pistils is to be found in the flower of the pitcher-plant. In many parts of the country the pitcher-plant is a rarity, and very few of the nature-lovers have ever seen the handsome blossom. The reason for this is that there are very few of the peat-bogs, or sphagnum moors, which the pitcher-plant and the sundew prefer. The peat-bog furnishes no nitrogenous food for plants, and it is said that for this reason the two plants mentioned have become fly-catchers in order to supply themselves with the nitrogen for which they hunger.

The flower of the pitcher-plant seems at a distance like a dull red rose; but great was my surprise to find the centre of the corolla closed by a little green umbrella with five ribs. On dissecting the flower, I found plenty of stamens clustering around the umbrella-stick, but was baffled in my search for the stigma. After considerable study, I discovered that the umbrella was a protruding pistil, with its outer end greatly expanded, and that the tips of the five ribs, curved under into little hooks, were the five divisions of the stigma, where pollen must be applied.

Now, with such an arrangement, the question is: how does the flower induce its guest to rub against these stigmas before he approaches the pollen? There are five entrances and five exits. Five of the dull red-and-green petals form landing-stages for insect visitors, and each leads to a low entrance under a hook of the stigma. This hook permits free entrance but doubtless deters the insect from leaving by the way he entered. The other five petals curve inward, over the umbrella, between the ribs, thus closing the exits to an arrival, but freely permitting a departure.

The doings of our visitor are now easy to explain. He arrives by the proper entrance, crawls under the stigma, and enters the cool, circular chamber, where he takes what nectar and pollen he desires. Then, seeking to leave the reception room, he finds that his easiest way out is to push one of the curved petals, a veritable swinging-door which opens outward.

The visitors best fitted to act as pollen porters for the pitcher-plant are the carrion-flies; and it is for them that the flowers assume their red colouring and veining, suggestive of raw meat. The flies also find a delectable feast in the dead insects floating in the "pitchers"; one species of flesh-fly,

the *Sarcophaga sarraceniæ,* has even received its name from the generic name of the plant. But we have not yet done with the many-sided relations which bind the pitcher-plant to the insect world. For insects it is not only a reception room and a tomb, but also a cradle. There is a moth called "Pappaipema appassionata" which breeds in the root of the *Sarracenia.*

PITCHER-PLANT

In addition to the flowers described, the following procure cross-fertilisation by means of the stigma placed well in advance of their anthers: huckleberry, sundrop, pipsissewa, shooting star, Indian cucumber-root, early blue violet, wintergreen and others.

But spreading stamens and protruding pistils are not the only variations possible in the positions of those organs. A third, and most interesting, combination has been effected to procure cross-fertilisation in the so-called dimorphic flowers, which we can best explain with some of the dainty little *Houstonias* in our hands.

QUAKER-LADY, OR BLUETS—*Houstonia cærulea*
April-July

These frail little flowers, which come early in the spring and bide with us into the scorching days of summer, are so minute as to appear at the first glance to be all alike. But a closer inspection discloses two kinds of these flowers. The plants grow in scattered bunches, or tufts, and all the flowers of one tuft will show protruding pistils at the openings of their throats, while flowers of another bunch will seem to have none. We must not, however, jump to the conclusion that we have found pistillate and staminate flowers. Carefully cutting open a number of the flowers, we find that long pistils and short stamens grow in some flowers, while short pistils and long stamens occur in others; and, with a microscope, the pollen from the short stamens is seen to consist of globular grains much smaller than those from the long stamens.

Suppose a bee of the genus *Halictus* thrusts his tongue into flowers of both kinds. In so doing, he will accumulate pollen in two rings—the lower being of the finer grains from short stamens, the upper of the coarser from long stamens. But in these visits, the tongue will brush against the pistils too, and the coarser, upper pollen can reach only the long stigmas, while the fine pollen will be car-

ried down to the short stigmas. But, in the latter case, in passing down the long tube, some of the fine pollen may easily lodge upon a long stigma. What then will happen? Nothing! For the long pistils are sensitive to the coarse pollen only, and cannot be fertilised by the finer. Hence, the long-stamen flowers fertilise those with short stamens, and vice versa.

The *Houstonia* is fertilised by the bees, *Halictus* and *Andrena,* and by the smaller butterflies, es-

HOUSTONIA

pecially the clouded sulphur (*Coleas philodice*), the meadow fritillary (*Brenthis bellona*) and the painted lady (*Pyrameis Cardui*). Flowers such as those of the *Houstonia* are called dimorphic, or "two-formed." Another example is:

Garden Geranium

As a study in dimorphism, the garden geranium is most valuable, as it is easy to obtain, and its parts

GERANIUM
(Dimorphic)

are large enough to be readily visible. But one must examine a great many flower-heads in order to find the long-pistilled variety. When I first noticed the long, conspicuous styles protruding from certain flowers, I mistook them for ripening seed-vessels, and was accordingly much surprised to discover at their tips small stigmas, five-parted and adhesive. These stigmas are held nearly an inch above the group of short stamens. If no other plants produced dimorphic flowers, we might consider these long pistils as accidents, or "sports," as they occur in very small numbers and very irregularly, while the flowers with very short pistils appear like quite normal flowers and, being very numerous, seem to be the standard type, of which the others are the exceptions.

In the short-pistilled flowers I discovered considerable self-fertilisation going on, while in those with the long pistils this would be impossible to occur.

Partridge Berry

This little plant, usually classed as dimorphic, sometimes becomes diœcious through stamens in

some flowers and pistils in others failing to perfect. This is true, also, of certain of the primroses and foreign species of the flax (*Linum grandiflorum* and *Linum flavium*).

PARTRIDGE BERRY
(Dimorphic)

Then there are flowers, called "trimorphic flowers," which bear stamens and pistils of three different lengths; but they so arrange matters among themselves that the pollen from the long, the medium, and the short stamens shall take effect upon the long, the medium, and the short pistils, respectively. The pickerel-weed (*Pontederia*), the purple spiked loosestrife (*Lythrum Salicaria*), and the wood-sorrel (*Oxalis*) furnish us with excellent studies in trimorphism.

STAMENS AND PISTILS DEVELOPING AT DIFFERENT TIMES
(Called "Dichogamy")

If, as we have seen, the position of the anthers and the stigmas assists greatly in the cross-fertilisation of the flowers, the time of their development with reference to one another proves to be still more effective.

There are vast numbers of flowers which ripen their stamens and their pistils at different times—a simple scheme distinguished by the clumsy name of "dichogamy." Such flowers are just as certain to be cross-fertilised as if they were separate staminate or pistillate flowers; which, in fact, they are, with the economic advantage that no flower is sterile. The scheme is simple and its purpose obvious to us; yet it formed the greatest stumbling-block in the path of true knowledge of this subject and wrecked the beautiful theory of Sprengel.

Many more flowers conform to this system than we at first suspect, and I wish to point out ways for recognising them.

We can see at a glance if the anthers are producing pollen, but not always can we tell if the stigma be mature. In some cases the stigma separates into two or more divisions, when it is ripe and ready to receive the pollen and transmit to the ovules the life-giving impulse. This we see in the flower of the wild geranium.

Other pistils, however, on maturing show no change of form, but become slightly furry, or sticky —as in the lilies—to hold fast the pollen grains; and in order to ascertain whether these pistils be ripe we must make a little experiment.

Choosing a stamen whose anthers are covered with pollen, we pull it out of the flower by means

of a pair of very fine tweezers, then rub its pollen against the pistil in question, and note whether it adheres or no. Frequently, the ripening of the pistil is announced, as in the ripening of fruit, by a change in color from green to some other tint more conspicuous; for in the Plant-world green counts as no colour.

We must always be on the lookout for this "dichogamy" in flowers, and, as an important part of our studies, determine whether the anthers or the stigmas be the first to mature.

STIGMAS DEVELOPING BEFORE STAMENS

(Called "Proterogynous dichogamy")

ENGLISH PLANTAIN; RIPPLE GRASS; RIB GRASS—*Plantago lanceolata* (*June-Sept.*)

This in America is an immigrant from Europe, a naturalised citizen to be found everywhere from June to September. From a group of lance-shaped and strongly ribbed leaves rises a tall stem, surmounted by a pointed cone of greenish buds and brownish flowers, so minute as to be almost indistinguishable. Around the flower-cone seems to float a hazy ring of pollen-laden anthers, as the rings of Saturn float round that planet.

If we watch a plant from day to day, we will notice that the brown flowers and the pollen ring seem

ENGLISH PLANTAIN

to rise higher and higher; and under the lens we distinguish four stages of the flowers, one below the other. Beginning at the top we find unopened buds; then buds with protruding pistils; then little florets with four brown petals, and four stamens whose long, slender filaments bear the anthers far out beyond the withered pistil. Below them, again, are the calices left empty by the falling of the flowers. A flower-head, with blooms in successive stages and a single floret with anthers, is shown in the accompanying sketch.

Since this flower has no conspicuous colour and no nectar, and the stamens swing loosely at the ends of long filaments, it is probably fertilised by the wind, according to Asa Gray—an unusual thing in an herb of this sort, not a grass nor a sedge.

COMMON PLANTAIN

COMMON PLANTAIN—*Plantago major*

The common plantain shown in the sketch will be found to develop its

stigma before its pollen. The pistil emerges from the little green flower, like a tongue, and later the stamens push out also; and as the blooming progresses upward, we find stamens, pistils, and buds in successive stages, one above the other.

GREATER MULLEIN—
Verbascum thapsius
June-Sept.

MULLEIN

We are apt to pass by in scorn this common and unattractive weed, which seems, with its presence, to make the waste places only more desolate. But though its leaves are like faded flannel, and its flowers are of an unattractive yellow, yet its erect spike possesses a certain rugged grace, and its flowers prove to be quite interesting in their manner of procuring cross-fertilisation.

As will be seen in the upper of our small sketches, the flower first opens its three lower petals, uncovering its prominent pistil, whilst

concealing the stamens under the two upper petals, as under a hood. In this state, an insect who calls will be sure to strike the pistil, and to leave upon it any pollen he may bring.

A little later, this pistil droops, the upper petals curl back, as in the lower small sketch, and the stamens fill the approach to the flower's throat, ready to give up their pollen to any passing guest.

Thus we see that the two stages of the Mullein flower, the pistillate and the staminate, are as distinct as if the flowers were monœcious.

FIGWORT

COMMON FIGWORT—*Scrophularia marilandica*
July-Sept.

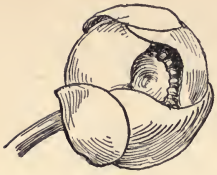
The common figwort exhibits a very simple contrivance for making certain that the bee shall touch the pistil before reaching the pollen. When the flower first expands the pistil alone is seen at the opening of the throat, where it is sure to receive any pollen that an arriving insect may bring. The

upper sectional view in the sketch shows the flowers in this stage and explains why the stamens are not visible, as they are curved down and backward, with the anthers down in the throat of the flower.

The next day after the flower has opened the pistil is seen to have wilted, and hangs like a tongue upon the lower lip of the flower, while the stamens have straightened up (as shown in the lower sectional sketch), thus bringing the anthers into a conspicuous position, where they can dust with pollen an approaching guest.

Mr. Gibson calls attention to the fact that the figwort strives to please and to attract the wasps in preference to other insects. Its colour is dull and sombre, the flavour of its nectar seems agreeable to wasps and not to others, and, lastly, its mode of inflorescence conforms to the habits of the former only, as will now be explained.

Most flowers growing in spikes or panicles bloom from below upward, to please the bees who visit them in that order; but the figwort and other "wasp-flowers" bloom first at the top and thence continue downward, for it is the custom of the wasps to begin at the top and work downward. Here we have a striking example of the adaptation of flowers to the tastes and habits of their insect affinities, how they offer hospitality and then exact a favour in



return. Such distinctly human traits should endear the flowers to us more than ever.

YELLOW POND-LILY—*Nymphæa advena*

May-August

POND-LILY

The yellow pond-lily has a somewhat similar mode of accomplishing the same end. As in the figwort, the stamens are immature, curved downward and out of the way when the flower opens its petals slowly, giving at first but a small triangular opening through which insects must pass directly to the broad, flat disc of the stigma. Later, the petals fully expand and the anthers straighten up and shed their pollen all around the heart of the flower.

This pond-lily possesses no fragrance, but it attracts the *Halictus* bees (according to Professor Robertson) and beetles named *Donacia piscatrix,* or the more common *Donacia subtiles,* a beetle about three-eighths of an inch long, of a dark green-bronze colour.

HORSE-BALM; RICHWEED
Collinsonia canadensis

COLLINSONIA

The horse-balm is an inconspicuous yet singularly interesting flower, whose mode of securing cross-fertilisation for a long time mystified so keen an observer as Mr. Gibson. He seems to be the first to solve the "mystery," as follows:

"What I observed is pictured severally in the figure, the flower being shown from above, showing the two spreading stamens and the decidedly exceptional unsymmetrical position of the long-style extending to the side. A small nectar-seeking bumble-bee has approached and in alighting upon the fringed platform grasped the filaments for support and thus clapped the pollen against his sides. Reasoning from analogy, it would, of course, be absolutely clear that this pollen has thus been deposited where it will come in contact with the stigma of another flower. So, of course, it proved. In the bee's continual visits to the several flowers he came, at length, to the younger blooms, where the forked stigmas were turned directly toward the front, while the immature stamens were still curled up in the flower-tubes. Even the un-

opened buds showed a number of species where the early matured stigma actually protruded through a tiny orifice in precisely the right position to strike the pollen-dusted body of the bee, as he forced his tongue through the aperture. Since the above was written I have noted the larger bumble-bees upon the blossoms. These insects have a different method of approach, hanging beneath the flower, the anthers being clapped against their thorax at the juncture of the wings, instead of the abdomen, as in the smaller bee."*

Other flowers of this class are the red baneberry, the blue cohosh, and the blood-root. Doubtless many more plants may be found to add the list, but by far the larger number of flowers perfect their pollen before their stigmas.

WILD GERANIUM
Cranesbill

STAMENS DEVELOPING BEFORE STIGMAS
(*Called "Proterandrous Dichogamy"*)

WILD GERANIUM; CRANESBILL
Geranium maculatum (*May-July*)

A very common flower which furnishes us with an

* *My Studio Neighbours,* by William Hamilton Gibson.

excellent example of this phase of cross-fertilisation is the wild geranium—excellent because it is very common and because its organs are so conspicuous as to be easily observed. On one flower whose stigma is yet closed we discover anthers in their prime, scattering pollen in copious store upon the honey-bees or those of the genus *Halictus,* or the syrphid flies which frequent it. On another flower we find that the pollen is all gone, the stamens are mere bristles, the anthers having withered and fallen off, while the stigma has expanded and is evidently ready to receive pollen.

FIRE-WEED

FIRE-WEED; GREAT WILLOW-HERB
Epilobium angustifolium

Another equally typical flower is the fireweed, whose showy spikes of magenta pink flowers make gay the newly cleared grounds, especially the burned places, in July and

August. Each flower has but four petals, and seems to have lost a lower one, which should serve as a landing-stage, but we may be sure from this that it desires to attract visitors who sip while on the wing.

APPLE—*Malus*
PEAR—*Pyrus*

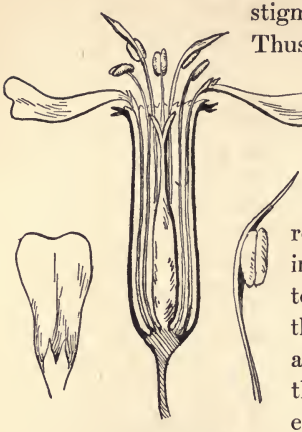
These are two common flowers, simple of structure and easy to investigate as to the development of their anthers and their stigmas. They are especially attractive to the honey-bees, each tree in bloom becoming vocal with their humming. I would suggest that the observer watch closely the bee at work, and notice that he gets well powdered with pollen about his head and chest at each flower, and, while he is on the wing to another blossom, he takes the opportunity to rub some of this off, into the pollen-bags of his hind legs. The work is done in a twinkling, but it is the secret of the bee's efficiency as a gatherer of pollen. What he rubs on his legs he is sure to carry home to his hive, while enough remains on his head to cross-fertilise the next blossom he visits.

FLOWERING TOBACCO

LONG-FLOWERED TOBACCO
Nicotiana longiflora

A very beautiful garden flower, occasionally escaping from cultivation, which at night produces great quantities of lovely white flowers, redolent with heavy perfume, and richly stored with honey for the night-moths. By day the plant appears positively shabby, with its numerous faded and wilted flowers; but these seem to absorb new life from the coolness of evening, and at night are all again stately and alluring. I was curious concerning two points in this flower: first, how the pollen which filled the opening of the throat was kept from the stigma; and, second, what was the use of the abnormally lengthened tube—too long for the tongue of any of our insects to sound.

One night I made sections of a great many flowers and buds and found that the pollen was shed just before the first opening of the flower, the anthers bursting and opening out into curious little capsules resembling cocked-hats. In older flowers whose pollen had been removed the pistil had turned to a dark brown colour, and had split into a cross-shaped spear on the front face of the



BOUNCING BET OR SOAPWORT

stigma, as seen in the sketch. Thus I discovered the flowers to be dichogamous. The long tube I found to be a veritable reservoir of honey, which flowed down the incline so as to be within reaching distance of the opening. An unusual construction to be noted is the insertion of the stamens far down the tube, at about one-third of its length, though of course the pistil necessarily must traverse the whole distance to the ovary in the calyx.

BOUNCING BET—*Saponaria officinalis*

This is a very common weed which came over from Europe to seek its fortune in the New World, with such success that it has spread far and wide as a wild flower. Its other name, soapwort, comes from the fact that the juicy sap of its stem, when mixed with water, produces a lather. The figure shows a section of the flower in its first stage, on opening, where the anthers with pollen are well in advance of the throat of the corolla, while the

stigma is yet undeveloped and hidden in the tube. After the pollen is shed this latter elongates and opens to receive the vivifying touch of an insect.

Notice that some of the stamens wear a little pointed hood, protecting their anthers, apparently as a rain-shelter.

Also another peculiarity should be remarked: At the base of each petal are two little points, or spurs, which act both as barriers against rain and to prevent the entrance of small, crawling insects, whose visits are not desired.

NIGHT-FLOWERING CATCH-FLY

NIGHT-FLOWERING CATCH-FLY—*Silene noctiflora*

Like the *Saponaria,* this is one of the pink family which immigrated to America from the Old World and brought with it strange, foreign habits worth studying. It has a way of opening its petals three nights in succession. Notice that there are five petals, and ten stamens, five of these opposite the petals, and five alternating with them.

The first night the opposite stamens shed their pollen, and for a few hours the flower is fragrant, attracting the night-moths.

The second night the petals open again, the fragrance has come again, and the alternate stamens are offering their pollen.

The third night, when the petals roll back for the last time, all the anthers have fallen, the filaments curl back, leaving the way clear for the open stigma to advance and receive the magic touch of the moth.

It is probable that the lure of fragrance thrice renewed is accompanied by nectar rising in three succeeding tides.

In the *Umbelliferæ*—such as the Angelica—the honey is exposed in open, saucer-shaped cups, where it can be obtained readily by throngs of short-tongued insects. In a whole head all the stigmas develop after all the pollen has been shed; thus the whole flower-head changes from the staminate to the pistillate condition. Accordingly, whatever pollen is received by the pistils must come from another flower-head, and not from an adjoining floret, thus obtaining a wider range of cross-fertilisation with all the attendant advantages.

CLOSED GENTIAN
Gentiana Andrewsii
August-Sept.

FRINGED GENTIAN
Gentiana crinita
Sept.-Oct.

CLOSED AND FRINGED GENTIANS

It seems a pity to destroy any of these beautiful flowers, but we must sacrifice one of each in the interests of science, making sections of them down their centre. Thus we shall see that the stamens, shorter than the pistils, develop their pollen first, and shed it outward; also that the pistils are like tall green vases, and that their stigmas part like two moist lips, presenting a sensitive surface on the upper side.

These flowers, standing so erect upon their stems,

might form veritable funnels to catch the dew and rain, but, to keep their pollen dry, the fringed gentian closes in cloudy or wet weather, and the closed gentian never opens at all. For this reason it has been thought that the latter flower was self-fertilised—a thing most unlikely on account of the positions and the successive maturing of the stamens and pistils. The colour, too, shows that this gentian strives to attract bees who alight upon it and tear apart the petals, as we would force our hands into a closed bag of peanuts. I have once had the pleasure of seeing a bumblebee thus enter a closed gentian with an assurance that proved he was an old burglar, experienced in "breaking and taking."

Many flowers, as we know, are arranged on tall upright stems, forming spikes most graceful to look upon, and collectively most attractive to the bees. But have we noticed that, as a rule, the lower flowers open first, and that the blooming proceeds upward? Have we discovered that usually the stamens develop when each flower opens, and that the pistil matures later, making the upper flowers, newly opened, staminate flowers, and the lower and older flowers pistillate ones? Such, however, is the case in many flowers growing in this way. We have but to examine the mints, the lobelias, the larkspurs, to assure ourselves of the facts, and perhaps to dis-

cover the reason; for we shall doubtless see a bee approach, pay his first call upon the flower lowest in the spire, and then, winding upward as if he were climbing a spiral stair, visit all the flowers in the order of their opening. Thus, if he has brought pollen from elsewhere, he will be sure to leave it on the lower stigmas, ripe and ready to receive it, and he will depart well powdered with pollen from the upper flowers newly blown. And we shall see the bee fly to another spire of flowers of the same variety, for such is his instinct and habit, and there again he will begin at the lowest flower, and continue as before, doing the day's work that he has planned for himself, but, incidentally, and all unconsciously, carrying pollen from flower to flower, and helping to create other flowers for other bees to visit another summer day. We have already remarked that the wasps pay their visits in the reverse order, and that their favourite flowers reverse the order of blooming, likewise.

I wish the reader to consider the marvellous manner in which the flower has arranged its own habits to conform to the tastes and customs of its most welcome and cherished guest. Each single flower does its best to please, by assuming the most attractive colour, putting out a convenient landing-stage, breathing forth the most alluring perfume,

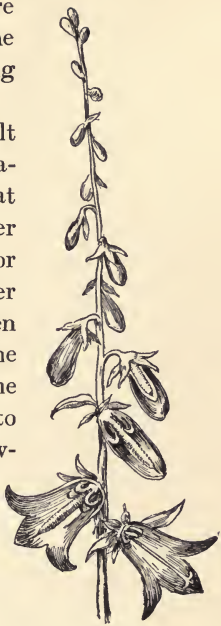
and then serving pollen and nectar where they are most conveniently consumed; in short, treating the guest like a spoiled and pampered favourite.

Then, notice that these separate flowers work together, blooming and shedding pollen as the bee wills it, and thus, by suave and courteous treatment, getting the most that the bee can give. This fine hospitality, and conformity in the habits of the flowers with those of the bee, even to the uttermost detail, seems to me to indicate either that flowers *think* and plan their own lives, or else that they are moulded and modified by an all-pervading Consciousness which makes all things and finds them good.

If the bee were the blundering, heedless fellow that his appearance and his habits imply, the chances for the transfer of a little pinch of pollen dust from one minute point to another minute point would seem exceedingly precarious. But the bee has very regular habits, after all. He does not zigzag from flower to flower, as is generally supposed, but, on one round from his hive, he sticks strictly to one flower, as if he were under the spell of some colour-charm, or obsessed with the desire for some sweet perfume. You will find much entertainment in watching certain bees invariably visiting flowers of the same kind in a gay border,

while avoiding others often more showy and more fragrant. Thus he is sure to distribute pollen among flowers of the same kind.

A curious and unexpected result follows this mode of cross-fertilisation. Any gardener will notice that seeds are formed only on the lower portions of any spike, the reason for this being that, by the time the upper buds have bloomed, shed their pollen and ripened their pistils, all the flowers in the vicinity have done the same and there is no more pollen to be had; hence all the upper flowers fade without fertilisation taking place.

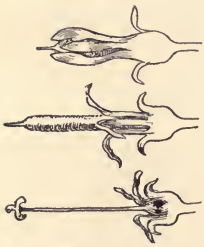


BELLFLOWER

BELLFLOWER—*Campanula rapunculoides*
June-Sept.

Let us take the bellflower, one of our most winning native flowers, as an illustration which exhibits interesting peculiarities of its own. Each flower is graceful in form and attractive in colour, but the lure and the charm of the bellflowers reside undoubtedly in their assemblage in long, tapering

spires, with just enough symmetry to make a decorative feature in any situation. These lovely bells, many times repeated, in varying sizes and positions, offer a study of unity in variety worthy of the cleverest pen or brush. Moreover, they display within their fragile bells an arrangement of stamens and pistils in progressive stages of development, which we will find amazingly interesting. Since we wish to follow it through its phases from the beginning, let us not follow the bee but, on the contrary, begin at the top of the spire and investigate some buds, slicing them open from summit to base with a sharp knife. Within, we shall find a group of undeveloped stamens, closely clasping an immature pistil which is about as long as they are.



MECHANISM OF BELLFLOWER

The next bud below shows the stamens have all curled back into the base of the corolla, leaving a tube of pollen clinging to the style of the pistil. The flower below has opened to receive its guests, and we see bumblebees, *Halictus* bees, and bee-like flies arriving, and invariably clasping the pistil as they plunge into the flower. Thus they soon take away all the clinging mass of pollen on their bodies.

While these visits are proceeding the style is growing out and the stigma is expanding, so that in the lower flowers we find it fully developed and open with three points turned back. The pollen has all disappeared and the stamens are curled up and withered. So that this blossom, which can have none of its own pollen, is ready to receive and hold fast any that is brought to it by a bee who swoops down to it from the upper blossoms of the bell-flower which he last visited.

The Venus's looking-glass, Canterbury-bell, and Platycodon exhibit the same course of development. The contrivance of stamens and pistils is in reality a simple mechanism for bringing about cross-fertilisation, the first of the sort we have seen, but henceforward we may search for such mechanisms, of which there are many.

Mint Family

All the members of the Mint family which I have so far been able to investigate, with the exception of the horse-balm, seem to have the common habit of developing and shedding pollen before the pistil ripens.

The *Scutellaria,* as in the sketch, and self-heal (*Prunella vulgaris*) have this peculiarity in

SCUTELLARIA

their stamens: the anther-cells do not both develop. Being placed in the hood of the flower, the front anther-cell alone would touch an incoming bee, and the back anther-cell, becoming useless, has been abolished.

This has not taken place, however, in the blue-curls.

BLUE-CURLS—*Trichostema dichotomum*

Here the stamens are elongated to such an extent that they emerge entirely from the hood and arch over and down toward the lower lip of the flower. This gives the flower a quaint, odd appearance, as if it were upside-down, and allows all the anthers to come into play, rubbing the back of any insect that enters. The pistil is short at first, but elongates as it ripens.

The garden sage goes through the same course of development, but in addition has perfected a most elaborate mechanism which will be described further on.

BLUE-CURLS

WILD IRIS AND POND LILY

Polygala sanguinea
July

This little flower is so inconspicuous as never to have won for itself a common name, yet when examined closely it displays a singularly interesting form. Upon a leafy stalk, from six to twelve inches high, grows a globular or elongated flower-cluster. If we remove a floret from the cluster we find it looks like a wee little bird with magenta wings and a yellow body. The wings are the two loose sepals of the calyx, and the corolla is a yellow tube with pistil and stamens within. The pistil has a very odd shape, with large ovary and curved style surmounted by a knob-shaped stigma. The florets develop on the spike from below upward, and as they shed their pollen and the stigma matures, the little yellow corolla assumes a tone of magenta. The result is that the flower-spike gradually assumes a deeper magenta, progressing upward from below; and consequently we can tell from the colour just which of the florets are in the staminate stage and which have developed their pistils.

POLYGALA SANGUINEA

CHAPTER IV

FLORAL MECHANISMS

WE have now come to the interesting group of flowers which seem to have invented for themselves ingenious mechanisms to insure their own cross-fertilisation, and to prevent self-fertilisation. Such a mechanism has been referred to in the case of the rose pogonia, as we saw on page 8, with its pollen retained in a lidded box that opens only as the bee makes its backward exit. Practically all the orchids have mechanisms more or less

complex, but many less rare flowers display equal versatility and cunning. On every botanical excursion I have discovered some secret trick, new to me, hidden in the calyx of some common flower, and I suspect that there are many hundreds of such delightful surprises yet awaiting us afield.

The nightshade puffs its pollen from a miniature bellows, the Oswego tea catches the bee in a miniature lasso, the cardinal flower pushes out pollen like chopped meat from a sausage stuffer, the mountain laurel shoots it as from a catapult, and the milkweed hangs its pollen on the leg of the bee, like a ball-and-chain, if it does not hold him altogether a prisoner.

The strange and surprising mechanisms with which the flowers make sure of their own cross-fertilisation are so various and so dissimilar that I become bewildered in attempting to classify them. Every flower seems to be a law unto itself, and to have worked out a scheme of its own to delude the unsuspecting insect. Some flowers have developed simple devices for protecting the stigma from its own pollen. Then there are arrangements like pistons for pushing forward the pollen, so that it will be gathered before the stigma is ready for any. In other cases the stamens move as if they were living tentacles, or springs of a catapult, to dust the visi-

tor with pollen. And besides all these, there are countless inventions, impossible to co-ordinate. They remind one of the model room of the Patent Office. Multitudes of miniature working models of machines are assembled: marvels of ingenuity and fertility of invention. But our floral mechanisms have this advantage over the patented prototypes—that they, at least, help to keep the plants alive, and to aid them in their struggle for existence, which cannot be said in favour of all products of human invention, for we know that many an inventor has starved.

TURTLE-HEAD—*Chelone glabra*
July-Sept.

This flower never opens its mouth very wide, nor does it show its pistil very conspicuously. This, as seen in the sketch, is concealed in the roof of the mouth, the stigma just above the opening, where it is sure to touch the back of an entering bee. Back of this the four stamens cluster into a sort of arbour or bower, united by their furry anthers, which are pressed close together, in pairs, face to face, thus holding in the charge of pollen till the right moment arrives.

Watch a burly bumblebee arrive with some pollen on his back. See him rub some of his charge

on the stigma, then plunge deep into the downy throat of the flower and probe for nectar. But when he is satisfied, see how he becomes entangled under the little bower of stamens, how he struggles to free himself, and, in so doing, pulls the anthers away from one another, and dusts his back with the fine, white pollen. The anthers do not return to their first position, but remain forever separated, and thus we can tell that a flower has received a visit. Any extra pollen left over is seen to fall back into the throat of the flower, upon its downy filling, where it may yet be gathered on the face and head of another bee, as powder from a powder-puff.

TURTLE-HEAD

As the pollen is locked up between the anthers until the bee has touched the stigma and fertilised it, the flower is practically sure that none of its own pollen can affect it.

Very often the mechanism of the flower consists of a little flap or valve closing at the proper time over the stigma, protecting it from the touch of pollen of home manufacture. We find contrivances

like this in the blue flag, the trumpet-creeper, and the monkey flower, which we will now examine.

THE LARGER BLUE FLAG—*Iris versicolor*
May-June

The iris has an ingenious mechanism of this sort, which works unfailingly. It has been called "The poor-man's Orchid," and its blossom resembles three orchid-blossoms, growing back to back, and radiating from a common axis.

WILD IRIS

A sectional view will explain the construction of the flower, and how it works to procure cross-fertilisation. In the centre of the flower just above the ovary is a well of nectar, and out of the centre of this rises a stalk which soon separates into three branches that resemble purple petals. They bend outward and downward and are tipped with two ears and a tongue. Then there are three erect purple petals, surrounding the centre of the flower, and, lastly, the three conspicuous, drooping petals or

"flags," rich purple in colour, and marked with dark veins. These latter attract the attention of the bumblebees, and form a welcome landing-stage for them. But where are the very important pistils and stamens? We have seen, without recognizing, the former in the three-branched structure first described, which consists in reality of three styles; and the stigmas are the little tongues at their outer ends, but the stigmatic surface of each, sensitive and receptive, is on the upper and outer side only.

Now, to find the stamens, we must lift up or cut away one of these arching styles. Hidden close under it we will discover the anther laden with pollen.

The bumblebee, a frequent visitor to the iris, seems to know exactly what is expected of him, for, alighting on the drooping petal, and following the guide-lines of its veins, he crawls crouching under the arched pistil and down the low-vaulted passageway it forms, till he is able to reach down into the nectary with his proboscis and drink his fill. But, to leave these close quarters, he must back out, and in so doing must necessarily brush his hairy shoulders against the anther, dusting himself with pollen. Backing still farther, he passes under the little tongue, which, lifting, closes against the ears

above, thus protecting the stigmatic surface from any of the pollen of home production.

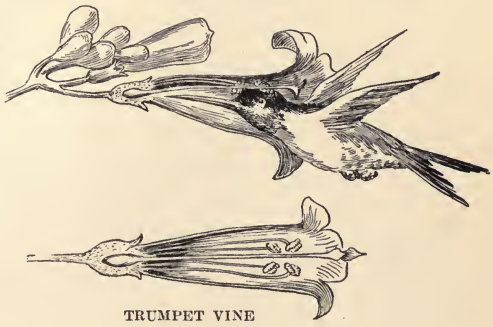
But the bee is now free to go to another flower, carrying his pollen load just where it will strike the stigma. However, as he passes under the arched canopy of the new flower, the little tongue will act not as a valve to close, but as a scoop to scrape the pollen off upon the stigma.

While the iris has ever been admired because of its grace and beauty, I believe that the reader will find it still more interesting on account of its ingenious adaptation to the work it has to accomplish.

TRUMPET-CREEPER—*Tecoma radicans*
August-Sept.

Though in no way related to the foregoing flower, the trumpet-creeper has learned in some way its secret device and makes use of its patent without paying royalty. In the showy trumpet-flowers we find pistils terminating in valve-like stigmas, which act exactly like those of the iris. The stamens are concealed in the roof of the flower, their four anthers being arranged in two groups, as seen in the figure. Being a native of the Southern States, where humming-birds are common, the flowers have so arranged their form, position, and colour as to offer an attractive welcome to the

humming-birds. The mechanism acts precisely like that of the iris, scraping pollen from an arriving humming-bird, but closing as he withdraws with home-grown pollen on his head.



TRUMPET VINE

The trumpet-creeper illustrates a principle in the fertilisation of flowers which we should point out. I have noticed that our own trumpet-vine rarely sets any seed-pods, and find in this fact the illustration of a principle in the fertilisation of flowers which should be explained.

In general, flowers are more easily fertilised by pollen taken from the flowers of another plant—less sensitive to pollen taken from another part of their own plant, and scarcely sensitive or entirely sterile to pollen taken from their own anthers. As a demonstration, Fritz Müller fertilised a Brazilian species of the *Bignonia,* which is the family name of our trumpet-creeper, with the following result:

(1) Twenty-nine flowers on two stocks with pollen of their own stock. All fell off in a short time.

(2) Thirty flowers on the same two stocks with pollen from others growing nearby. Only two flowers developed fully, but most of them remained longer upon the stem than in the previous case, and many showed a commencing enlargement of the ovary.

(3) Five flowers on one stock with pollen from another growing at a distance. All were fruitful.

As our trumpet-vines in the North are few and far between, they do not get that crossing of the pollen from vines widely separated, so necessary for making seeds. It is stated by Müller that the valve on the stigma of the trumpet-vine closes permanently as soon as it has received any pollen.

MONKEY-FLOWER—*Mimulus ringens*
June-Sept.

This little flower, whose saucy corolla seems to betray a disposition toward quaint, odd habits so much resembles a face that we must speak of the pistil as a "tongue"—a most sensitive little tongue with a slit or division at its tip. At the taste of the pollen which it desires, this slit in the tongue closes and holds fast the dainty morsel.

Oswego Tea; Bee-balm—*Monarda didyma*
July-Sept.

This member of the Mint family has an interesting arrangement of pistils and stamens. All of them are held up out of way of insect approach by a tube-like fold in the upper petal. I have noticed, however, that the bases of the filaments partly bar the way to the throat and honey passage. Therefore, I tried a bristly head, like that of a bee, thrusting it far into the throat; and upon withdrawing it I entangled the filaments as by a lasso, pulled out the stamens, separated the anthers, and procured a charge of pollen. This act also liberated the unripe pistil which, developing later, and falling down, was now in a position to receive other pollen.

OSWEGO TEA

Insect visitors are the bumblebee and butterflies, *Colias philodice* and black-and-tan *Danias archippus*.

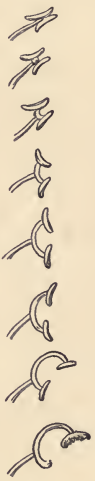
Another of the Mint family should find its place here among the remarkable floral mechanisms.

SAGE

GARDEN SAGE—*Salvia officinalis*

The flowers grow in a graceful spire, and bloom from below upward. Here, again, we must make sections of an unopened flower to understand clearly the workings of its scheme. In the buds we find the beginnings of four stamens, but two of these at the back of the throat are destined to remain as little embryo things, coming to nought. The pair in front promise at first to bear anthers of the usual sort—two capsules on a long filament—as seen in the first diagram. But the anther-cells gradually separate from each other, growing wider and wider apart, till they stand facing each other on the tips of a crescent. Then the inner anther-cell, nearest the throat of the flower, fades and falls, and the little crescent becomes hinged on its support so that it rises and falls with the remaining cell full of pollen, just as an old-fashioned well-sweep rises and falls with its bucket.

Now the flower is ready to open and to receive the call of a bee. For such a visit it has not long to wait, for the bee has already come to the flowers lower down on the spike, and gladly mounts to this one, newly opened, with its fresh store of nectar. He crawls deep into the blossom; and in reaching down for nectar he strikes his head against the inner end of one of the crescents, causing it to tilt and bob down its anther bucket, thus spilling pollen upon his back.



DEVELOPMENT OF ANTHERS OF SAGE

But Nature sees to it that he does not self-fertilise the flower. The pistil is still too short to reach his back, so the bee, having finished with the youngest flower of the spike, carries his burden away to an older flower, low down upon another spike: a flower which has been open a day or more, and whose pistil has so elongated and curved downward as to obstruct the entrance and surely to take up some pollen from the bee passing under.

Thus is cross-fertilisation accomplished. It is an important business, even though the trick contrivance of the pollen duster reminds us of the

pranks and capers and practical jokes of merry-makers in carnival time.

The perfect adjustment of the apparatus and its unfailing operation fills us with astonishment, and leads us to wonder if some superior intelligence, some *deus ex machina,* devised it, and created it all out of the delicate and fragile material of which all flowers are built. But as such speculations are unscientific we must postpone them till such time as we shall have fuller knowledge from which to make deductions.

Most of the floral mechanisms are economic devices to save pollen and to make the most of the precious stuff. The great pine-trees may scatter their pollen by the bucketful upon the wind, and the Indian corn may throw it away in wanton profusion, but the flowers seem to have learned to be thrifty with theirs—at times even parsimonious.

The bellflower, where the stamens fall away, leaving the pollen clustering about the pistil, is a little too lavish; and its relatives, the lobelias, have improved upon its ways.

PALE SPIKED LOBELIA—*Lobelia spicata*
July-August

This flower presents a decided improvement upon the bellflower. The stamens similarly unite into a tube around the undeveloped pistil, and shed and

retain their pollen within. Then the stigma grows, elongating its style, and shoving forward its curious, star-shaped stigma, which, acting like a piston in a cylinder, gradually pushes before it the charge of pollen.

Now of course the pollen must escape, so it emerges through a small opening at the outer end of the stamens, a little at a time. If we take away the supply more is pushed out, reminding us of a minute sausage-stuffer at work, squeezing out its meat. When at length all the pollen has gone, out comes the stigma, and becomes adhesive and ready for the touch of some pollen from another flower.

PALE SPIKED LOBELIA

CARDINAL FLOWER—*Lobelia cardinalis*
August-Sept.

This flower supplies its pollen in small instalments in exactly the same manner as the pale spiked lobelia, and it is more convenient to study because its working parts are so much larger.

We might almost assume that the piston-and-cylinder scheme had been invented by the lobelias, and then the idea had been appropriated by the

LOBELIA CARDINALIS

numerous families of the Composites; for each and all of them have adopted a similar mechanism. When we speak of a daisy, thistle, or some other branch of this family, we mean the flower-head, composed of an enormous number of minute florets packed closely together, competing with one another, yet working together for the good of their race.

These little flowers are of two kinds: tubular flowers, as seen in the sketch of the Joe Pye weed, and ray flowers, as seen in that of the lion's-foot. Both kinds are found in the head of the Black-eyed Susan, the white daisy, the sunflower. They are quite variable as to their stamens and pistils, sometimes being perfect flowers, sometimes pistillate only, and again they are neuter or sterile.

JOE PYE WEED—*Eupatorium purpureum*
August-Sept.

In late summer every moist place is crowded with a dense growth of so-called weeds, of various forms and hues, but old Joe Pye towers above them all, lending a dignity and charm of colour, and the

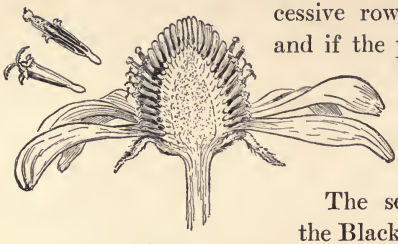
scene reminds us of a town in the Old World dominated by a cathedral tower, stately and sombre. The purple flower-clusters are made up of numerous tubular, perfect flowers, interspersed with chaff. A small cluster is shown in the lower part of the drawing, on the left, and a single flower on the right, both greatly enlarged.

In the centre of each flower is a pistil, surrounded and clasped by stamens whose anthers unite into a tube to hold the pollen. The corolla consists of a tube opening out in five curving points..

When these first expand the pistil is shorter than the stamens, but it gradually grows, pushes out the pollen where the bees can get it, and then, still elongating, develops its stigma to be fertilised.

In daisies and dahlias we can see a very pretty demonstration of this action. Around the base of the central flower-cluster we see a ring of pollen like a golden crown. Watching the flower from day to day, we see this ring climb higher and higher, as the suc-

JOE PYE WEED



BLACK-EYED SUSAN

cessive rows of pistils grow, and if the pollen is not gathered by bees it will fall upon the ground as a fine, yellow powder.

The sectional sketch of the Black-eyed Susan shows the flowers in successive stages of their development: buds above; then open flowers with pollen appearing; yet lower, the expanded stigmas; and, lastly, the pistils fallen and the seed maturing.

Ray flowers have the same construction and action as the tubular flowers, and are but a more showy development of them.

LION'S-FOOT—*Prenanthis serpentaria*
July-Sept.

At first glance this resembles a minute lily, but upon examination it proves to be made up of numerout perfect ray flowers as shown in the sketch. At the right hand is a single flower, separately.

The corolla, which in Joe Pye is a tube, is here split open, flattened out, and curved back. But the five little points are still ornamenting its outer edge; and we find a suggestion of these points in

the varied tips of the rays of daisies and sunflowers.

LION'S-FOOT

In the Composite family there are various combinations of tubular flowers and ray flowers; the latter are often pistillate only, as in the common daisy, but often without stamens or pistils, as in the Black-eyed Susan. The ray flowers put forth their banners in order to attract the insects to alight upon them, then crawl over the flower-head and scatter pollen of the upper flowers downward upon the waiting stigmas, thus insuring cross-fertilisation within the flower colony, or taking some away to the next flower visited.

The arrangement of the Composites has the following in its favour:

Combination of flowers make them conspicuous.

Nectar is easy of access.

Pollen mechanism is an obstacle to self-fertilisation but favours cross-fertilisation.

Insects may visit many flowers in a very short time.

Long seasons procure many visits from many kinds of insects.

(Müller states that 152 kinds have been counted as visiting a single flower of this family.)

The close packing of the flowers among the Composites shows the excellence of the team-work; for this family has prevailed over many others in the struggle for existence, as witness the extraordinary success with which the ox-eye daisy, an immigrant from Europe, has flourished and spread until it has won the name of "The Farmer's Curse."

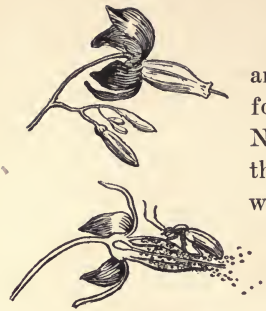
Violets and Pansies

The violets of the woods, and their aristocratic relatives, the pansies of the garden, have their

anthers arranged close about the pistil to hold the pollen and deliver it at the moment it is called for. The figure shows a section of the pansy with the stamens clasping the style, and the anthers, which open inward, shedding their pollen. The stigma protrudes and opens like the tip of an elephant's trunk, with two small lips. Now, supposing the bee arrives with pollen on his head and back. He is sure to deposit some of it upon the stigma, then, in reaching for nectar, he will disturb the position of the stamens, and thus set free fresh pollen and receive a shower of it on his head and back. Now he backs out and we might expect him to leave some of this fresh pollen on the stigma; but the lower lip of the latter closes up over his head, and self-fertilisation is thus prevented, just as is the case in the iris.

PANSY

It is amusing to notice that the bumblebees and honey-bees, habitual visitors, usually alight upon the broad lower petal, then whirl around to the upper petals, with their heads downward, this reversed position giving them better access to the nectar-well within.



NIGHTSHADE

NIGHTSHADE—*Solanum Dulcamara*

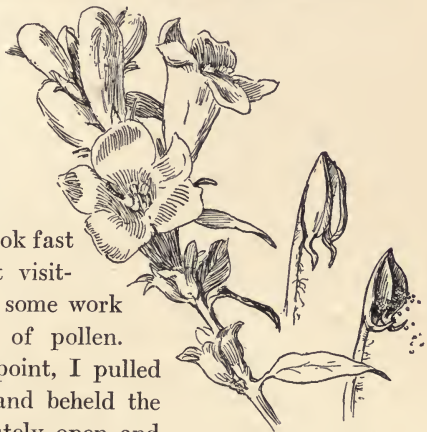
Again we find the ingrowing anthers, and the pollen tube formed thereby, in flowers of the Nightshade or Solanum family—the potato, tomato, and Jimson-weed. The fact that the anthers form a close pollen-chamber, opening only in two small pores or "chinks" at the apex, set me to speculating as to their secret mode of shedding pollen. At last I suspected that the pollen-chamber was an air-bag intended to blow out the pollen when compressed by some clasping insect, just as the little sand-stars blow out their spores when touched. To test this I took a flower of the nightshade and placed it upon a strip of glass, and at the apex of the anthers put a drop of adhesive Canada balsam. Then, with a quick movement, I flattened the little balloon formed by the anthers, thus compressing the air within. I now examined my Canada balsam under the microscope, and was gratified to find a little cloud of pollen-grains adhering, like a cloud of smoke around a cannon's mouth.

Thus I believe I have solved the mystery of the

flowers of the Solanum family. Their stigmas protrude and are fertilised; then the pollen ripens in the little balloon and remains there till some insect alights upon it, hugs it roughly for a support, and thereby fires the charge of pollen, some of which is sure to adhere to his abdomen. The sketch shows clearly the arrangement and action of the parts.

DOWNY FALSE FOXGLOVE—*Geradia flava*
July-August

When prying into the secrets of this flower, I was delighted to discover a new floral mechanism. I found that each of the four stamens bore anthers with little spikes, much like the barbs on fish-hooks, and reasoned that these little appendages were meant to hook fast upon the insect visitor, and then do some work in the delivery of pollen. So, with a pin-point, I pulled at these hooks and beheld the anthers immediately open and



GERARDIA FLAVA

discharge some pollen. I had the combination, and could open the storehouse at pleasure. No need to see the Peacock butterfly at his work. The dent. If the butterfly brings pollen he will deposit some on the prominent pistil; then, thrusting his head into the corolla in search of sweets, he is pretty sure to get entangled in some of the hooks of the anthers, and in freeing himself he will set the mysterious springs in motion, throw open the little pollen safes, and bear away some of their precious horde to another waiting flower.

The sketch shows a cluster of flowers and buds, and two stamens greatly enlarged, the anthers of the one closed, and those of the other with hooks pulled, doors open, and pollen falling out.

The Bean Family

Among plants as among human beings, some odd peculiarities seem to "run in families," and to be more pronounced in some members than in others. Let us quiz the manners of the members of the Bean family, and see how some behave. Some of them are pronounced misers, and are very stingy with their pollen store. In almost every case they keep it shut up in a boat-shape receptacle, and cover this with a neat roof.

THE LUPIN

Dr. Henry Smith Williams in his *Life and Work of Burbank* tells us that the peas and beans of the vegetable garden keep all their pollen at home and are self-fertilising. However, the flowering sweet pea, the pink locust and the lupin bear evidence in their flowers that they invite the bees to enter. The colour and fragrance alone show this intention, and the mechanism is perfectly comprehensible. Glancing at the sketch, we see that the stamens and pistil are protected from rain and marauders in the boat-shaped lower petal, which forms a handy landing-stage, but one which will give way a little under the weight of a bee. Now, it happens that the stamens and pistils are so stiff that, as the boat sinks, they come up from the main hatch and touch the under side of the bee. The pistil, being the longer, comes up first and gets a touch of pollen if any has been brought from afar; the stamens then follow and give up their store.

SWEET PEA

Then the bee, having quenched his thirst, flies away; the boat rises into place again, and the

stamens and pistil hide in the hold of their frail barque, the roof-petals close, and all is as before, save that the act of cross-fertilisation has been accomplished.

A perfectly similar action takes place in each little floret of the clover. Their construction is exactly the same; only they are so much smaller that they can admit but the head of the bee. The clover florets are closely packed together, and hence have all the advantages of mutual association, like the daisies; but they are not Composites, and run no risk of self-fertilisation. They are, in fact, absolutely dependent upon the visits of bees, as the following story will demonstrate:

In the early days of the settlement of Australia, the farmers there sent to England for clover-seed, which they planted and grew with success. The first crop in that virgin soil produced magnificent flower-heads, but no seeds. The valuable plant refused, mysteriously, to propagate itself. What could cause it to be thus fickle? The answer to the puzzle was "no bees." In the absence of their bee-affinity, the clover refused to produce its kind; so the Australians were obliged to send for bees, and to acclimatize them there. The bees and the clover resumed their usual life work, and lived happily ever after.

Several flowers of the Bean family, by the growth and elongation of their stamens, force the pollen forward into the bow of the little boat-petal, where it remains in a compressed state till something happens to release it.

GROUND-NUT—*Apios tuberosa*
August-Sept.

A floral surprise awaits you in the flower of the ground-nut, a native wild flower, whose beauty passes unappreciated, probably because its handsome clusters are composed of flowers of such deep maroon and delicate lilac as to attract little attention, though the bees find them through their rich fragrance. The single flower has a strange, quaint form, remotely resembling that of the pea or

GROUND-NUT

bean. There is the roof or hood, and there are the two wings; but in this case the wings hang down to form the landing-platform, as in the drawing. And there, too, is the boat, but curved upward like a horn whose tip reaches into the tip of the hood and is held there, gently but securely, till a visitor arrives. No stamens or pistils are visible. But let a bee arrive and begin his rummaging for nectar. The little horn is displaced, its tip escapes and splits apart, the enclosed pistil and the stamens push forward, and out comes a charge of pollen, where it will reach the bee and dust him over.

We can play the bee and set the mechanism in motion by means of a pin, and we will find keen delight in watching the little horns of plenty invariably discharge their golden store. When stamens and pistils have once forced their way out of the horn they do not return again, and if they are visible in a flower we know they have already been released by the visit of a bee.

Several of the Desmodiums are more impetuous in their giving.

Tick Trefoil—*Desmodium nudiflorum*
July-August

This and the Canadian species of the same genus hold their pollen so tightly compressed in their

little boat-petals that the least touch will send it flying. A honey-bee or one of the smaller bees who comes to get nectar is welcomed with a whole shower of pollen as soon as he alights. But the bees do not seem to mind these wanton pranks that we would consider very inhospitable, for they keep on their round of visits, carrying some pollen, and receiving more. Similar frivolous welcomes are offered by the *Genista tinctoria,* or whin.

TICK TREFOIL

But it is not alone in the Bean family that we find flowers shooting off their pollen. Some of the Heath family have learned similar tricks worthy of April First.

MALE BERRY—*Andromeda ligustrina*
(called by some botanists *Lyonia*)
June-July

This is a shrub growing in moist thickets which lives like a clown by its jokes. Let Mr. Gibson describe its conduct.*

* From *Blossom Hosts and Insect Guests,* William Hamilton Gibson.

"I recently observed its singular reception to the tiny black-and-white-banded bee, which seems to be its special companion, none the less constant and forgiving in spite of a hospitality which, from the human standpoint, would certainly seem rather discouraging. Fancy a morning call upon your particular friend. You knock at the door and are immediately greeted at the threshold with a quart of sulphur thrown in your face. Yet this is precisely

ANDROMEDA

the experience of this patient little insect, which manifests no disposition to retaliate with the concealed weapon which on much less provocation he is quick to employ. He alights upon one of the tiny bells, scarce half the size of his body. Creeping down beneath it, he inserts his tongue into the narrow opening. Instantly a copious shower of dust is poured down upon his face and body. But he has been used to it all his life, and by heredity he knows that this is Andromeda's peculiar whim,

and has to humour it for the sweet recompense which she bestows.

"This species of the Andromeda is a shrub of about four feet in height, its blossoms being borne in close panicled clusters at the summit of the branches. The individual flower is hardly more than an eighth of an inch in diameter. The first sketch (page 110) shows the remarkable interior arrangement of the ten stamens surrounding the pistil. The second presents a sectional view of these stamens, showing their peculiar S-shaped filaments, and ring of anthers, one of these latter being shown separate at the left, with its two pores and exposed pollen. The freshly opened blossom discloses the entire ring of anthers in perfect equilibrium, each with its two orifices closed by close contact with the style, thus retaining the pollen. It will readily be seen that an insect's tongue, as indicated in the drawing, in probing between them in search of nectar must needs dislocate one or more of the anthers and thus release their dusty contents, while the position of the stigma below is such as to escape all contact."

This saving up of the pollen and then throwing it forcibly at the right moment seems a family trait of the Heath family, seen to better advantage in the lovely flowers of the mountain laurel.

MOUNTAIN LAUREL—*Kalmia latifolia*
May-June

It was once supposed that the "beauty of the flowers was their sole excuse for being," and certainly the laurel has this excuse in full measure, for without doubt it is one of America's loveliest of native flowers. But we know too much about the ways of the flowers to suppose that the beauty of this one alone has helped it to survive long ages of competition, and when it blooms we straightway pry into its waxen chalice, and seek to discover the secret of its fair victory.

Like the rhododendron and the Andromeda, its anthers are twin meal-bags full of pollen, mounted upon long, spring-like filaments forming veritable catapults. Each corolla is provided with a ring of twelve small pockets, which gently hold the anthers and keep the filaments curved back in a state of tension, all round the central pistil.

MOUNTAIN LAUREL

Thus the flower blooms, and thus it will remain unless some evening a night-moth, attracted by the white blossoms and by their fra-

grance, arrives and reaching down for nectar disturbs the arrangement of the stamens. A little touch will derange the equilibrium and one or several anthers will be released from their pockets; they will fly up with a quick snap, and their pollen will be thrown up forcibly against the moth's body and cling to his woolly covering. And it should be noticed that if the moth brings pollen from another flower he is likely to leave some on the prominent stigma, while his body, at the moment of the explosion, acts as a bulwark to protect the pistil from the discharge of the numerous little catapults he has set in action. No more perfect mechanism could be devised, but the wonder of it is that it can exist in such frail and diaphanous material, and that it can come into existence within a bud, its complex parts first folded and distorted, but sure to unfold, adjust themselves with precision, and work unerringly at the slightest touch.

With the mountain laurel blossoms we can play the moth. Making believe that a pin is our proboscis, we can loosen the anthers from their places in the little pockets and discharge a whole broadside of these weapons and see a cloud of flying projectiles.

Should we catch some of the pollen and ex-

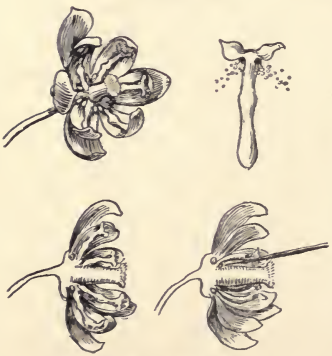
amine it under the microscope we would find that it is an ammunition forbidden by the rules of modern warfare, for its grains are more or less connected by delicate filaments, like the chain-shot of olden times; but this arrangement makes the grains more likely to adhere to the body or entangle the legs of the friendly foe.

There are doubtless other flowers, yet to be discovered, which throw out their pollen in an explosive manner.

A less impetuous flower is the barberry.

BARBERRY—*Berberis vulgaris*
May-June

Each little yellow flower resembles the mountain laurel in the situation of pistil and stamens; but these latter are not caught back and held in little pockets, and when in action they do not violently throw their pollen. They are not catapults, acting with a spring, but, more remarkable still, they are



BARBERRY

endowed with life and voluntary motion, and are able to feel and to move, just as the leaflets of a sensitive plant feel and move. Make the experiment upon a blossom of touching the centre with a pin, and you will immediately see the stamens shrink and close toward the pistil, exactly as a sea-anemone closes its little tentacles at the slightest touch.

The purpose of this wonderful mechanism is very easy to understand. Our front view of the flower shows the blossom as the bee finds it, with the six little stamens wide apart against the petals, their small pollen-chambers open and ready to give up their contents. The first sectional view likewise shows them in the same position. Now, suppose a bee lands on the flower, and, holding himself in an inverted position, thrusts his long beak and tongue into it and probes the nectar glands in the centre. He is sure to touch some of the sensitive stamens, which immediately respond, curving forward and clasping around the intruding proboscis and dusting it with a charge of pollen.

Let the bee carry some of this to the next blossom. He will be sure to brush some pollen against the large stigma before the stamens have had time to move up and clasp him as before. Thus the bee will move rapidly, fetching and carrying pollen

from flower to flower, till all have been satisfied and the little ovules are vivified and started on their way to become bright and attractive red berries in the coming autumn.

POINSETTIA—*Euphorbia pulcherrima*

This flower, blooming in greenhouses about Christmas-tide and embellishing with its scarlet leaves many a holiday feast, reveals a fantastic trick with its stamens, rivalling the antics of the clowns in the Christmas pantomime. A glance at the poinsettia will show that the scarlet leaves are not petals, and that the flowers are not huge and showy and solitary, but small, inconspicuous and clustered into an umbel at the centre of the showy rosette of leaves. And another oddity will be observed: namely, that there is at the side of each flower a huge nectary which resembles a little yellow drinking-fountain full of some adhesive nectar. The stamens grow thickly upon the flower, their filaments being exceedingly

POINSETTIA

brittle. When an insect arrives to drink he is sure to disturb them, and they break away and jump off bodily, as if fleeing from some pest. They jump, they skip, they turn somersaults in the air, and some of them fall into the nectary or upon its adhesive borders, whence they are carried to pistils of other flowers by adhering to insects such as flies, beetles and *Hymenoptera,* who come to drink.

It is no uncommon trick among flowers for the entire stamens to come away. This occurs most interestingly in the jewel-weed.

JEWEL-WEED

JEWEL-WEED; TOUCH-ME-NOT
Impatiens biflora
July-Sept.

In moist and shady places this plant grows in great abundance, bearing profusely its showy orange-yellow blossoms, shaped like Oriental slippers without heels but with pointed toes curved upward into hooks. For some time I supposed that I had discovered staminate and pistillate flowers on this plant; but closer observation showed that the stamens grew directly upon the pistil, and pro-

tected the flower completely from its own pollen. The stamens form an odd group, much resembling a molar tooth with five prongs, and these prongs grasp the pistil and hold fast till all the pollen is shed. Then the whole "tooth" loosens and comes away and the exposed stigma perfects. The jewel-weed is visited by bees, and also by humming-birds.

This curious shedding of the stamens I have found to occur also in another Impatiens flower, which is sold by the nurserymen as a winter house-plant. The flowers are bright pink in colour, and bear five rounded petals, opening flat and wide; hence they do not resemble, either in form or colour, their native sister, the jewel-weed, but their stamens have exactly the form and habits of those of the latter flower.

INSECT PRISONS

It is not quite accurate to speak of friendly relations as existing between flowers and insects. As a rule, the flower makes use of the insect with lofty superiority, as man makes use of a beast of burden, feeding him and bullying him to do its will. Sometimes the flower entraps its unsuspecting visitor and holds him an unwilling prisoner. We have seen how this happens in the case of the English Lords

and Ladies. In America we find the same thing recurring in the Dutchman's pipe.

DUTCHMAN'S PIPE—*Aristolochia Sipho or Macrophylla*
May-June

The extraordinary shape of the flower is perfectly understood from its name. The front of the "bowl" is brown, flat, and three-lobed. In the centre of this is a small opening giving entrance

DUTCHMAN'S PIPE

to a chamber which curves downward and then upward. The stamens and the pistil are at the further, upturned end. The pistil is the first to perfect, and thus receives pollen brought from another flower by early small insects such as gnats and flies. These, however, are not able to crawl or fly out the way they came, and are held prisoners till in due time the anthers shed their pollen. Then the tube of the flower withers and hangs limply down-

ward, permitting the insects to go their way.

Though the vines grow luxuriantly about my home, bearing numerous flowers, I have failed to find any of them bearing seed-pods, from which I conclude that the Aristolochia is absolutely dependent upon insects, and that its favourite guests in the insect world are not to be found in these parts, though we have plenty of other and less useful sorts. Possibly, however, the cause may be that too few vines grow in this vicinity to furnish the requisite crossing of pollen with distant flowers, as was noted in the case of the sterility of the trumpet-creepers growing hereabout.

MILKWEED

MILKWEED—*Asclepias syriaca*
July-August

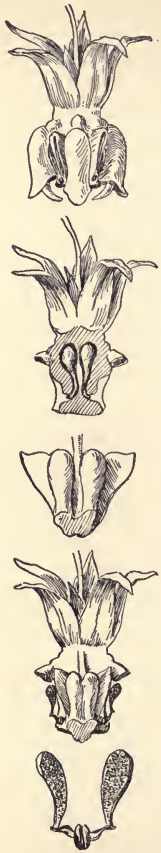
The most complicated mechanism among our

flowers, with the exception of the orchids, is that of the common milkweed. It seems strange that this rank herb should resort to such elaborate means to procure cross-fertilisation, and remarkable also that no similar mechanism has been evolved by other plants. The milkweed shows inventive genius. Its flowers are very small and clustered in a loose bunch, of delicate lilac or lavender-brown colour, and emit a heavy, cloying fragrance. We see them in the opposite drawing as they droop in a loose bunch of some twenty florets. Around and upon them various insect visitors are always to be found, and we usually see the flowers tossing and swaying under their eager thrusts. We see the insects cling and swing by their hind legs clasped against the neck of the flower, as in the sketch, and sometimes a leg caught as in a trap, while the whole cluster quivers as the insect frantically strives for freedom.

BEE ON MILKWEED

Let us pluck a single floret, like the topmost sketch, and examine it.

We see the calyx bent back, and the narrow neck to which the insects cling, and five nectar-horns,



MILKWEED

true horns of plenty, in which they eagerly drink. But the stamens are not easy to find even with a microscope, and are revealed only by dissection. Having thus separated the parts, I can best explain their complex arrangement by building them up again.

Upon the calyx grow two pistils, but these are embedded in a fleshy column and their stigmas can be reached by the pollen only through five small holes.

A single stamen is shown in the adjoining sketch. It has a very short filament, two anthers, and two wing-like appendages. Five of these stamens cluster round the column and shed their pollen inward against it, the wings of one stamen meeting the wings of stamens on either side to form a little tent or pocket which we will call the pollen-chamber.

Now the pollen in the milkweed is not the usual fine, mealy substance, but a mass like a croquette,

shaped like a mutton-chop, and so minute that it can scarcely be discovered without a magnifying glass. One chop grows in each anther, and is connected with another chop by what seems to be a little steel bow, bearing in its centre a minute spring catch, destined to make itself fast to the leg of an unwary bee or butterfly.

The pollen masses lie on either side of the stigmatic orifice, but hidden from view by the anthers —all save their little spring catch, which is visible in the first sketch as a bright black dot at the bottom of the pocket-slit of pollen-chamber.

Now, the principal organs of the flower are in place, yet it needs the nectar-horns to offer their attractions of sweets and perfumes for the insects. There are five of these horns springing from below the calyx and curving downward and under the lower end of the column, the spaces between them

MILKWEED

disclosing the slits in the pollen-chamber, and the little spring catches, but hiding the anthers from view. We give one sketch showing a view of the floret from below, and another showing a horizontal section, cutting pollen-chambers, column, and ovary.

Now that we know the construction of the flower, we will next find out the purposes of all these elaborate arrangements. Let us go forth early some summer morning to our milkweed plant and watch its complex machinery in operation.

The bees and butterflies are there before us, bending down the flowers with their weight. They clasp the neck of the column with their hind legs and thus, hanging head downward, they curve their bodies and reach upward into the nectar horns for food; then, on leaving, they loosen their hold, and their hind legs slip down into the little pockets of the pollen-chambers, where they are caught and held more or less firmly. Here is a predicament. The insects struggle and pull till their hind legs slip farther and farther down the slit, and at last come out, bringing a pair of pollen-chops snapped fast by the spring-catch, as shown in the lower sketch. But as soon as the pollen masses are withdrawn their little connecting bow dries and curls in such a manner as to fold them, one upon another, and thus

they can easily enter the slit of a pollen-chamber on another flower.

The insects seem to learn nothing from their unpleasant entanglements, for they fly to a new flower and repeat their exploits—with this difference, however: When their hind legs enter the slotted opening, they drag the pollen masses into the pollen-chamber and leave them there at the stigmatic opening, where they will give life to the ovaries within.

Truth compels me to state that the action described does not occur for every visit, nor yet once in very many visits. On a flower-head I examined there were forty blossoms, and each one received the visits of at least twenty insects, making eight hundred chances for fertilisation to take place; yet this plant made but two seed-pods. But none can deny that the mechanism works sufficiently well to propagate the milkweed plentifully and lustily.

Fritz Müller gives a sketch of a butterfly's legs laden with no less than eleven bunches of pollen, or spring clips, and Mr. Wood, the botanist, received from a bee-grower of California a box of bees whose legs were so clustered with milkweed pollen that they could not do their work, and were supposed to be the victims of some disease, or to bear some strange fungous growth.

In watching the insects at work on the milkweed, it is quite exciting to see their struggles for freedom, and to speculate whether they will shake themselves loose, or remain entrapped to die of starvation.

All the members of the Milkweed family possess the mechanism described, including the gorgeous butterfly-weed, shown in our coloured plate.

SPREADING DOGBANE—*Apocynum androsæmifolium*
June-July

This flower sometimes entraps and holds its eager guests. The dogbane is a low shrub bearing pinkish white blossoms resembling the bells of the lily-of-the-valley. Its stigma is two-lobed, with a notch between, and in this notch the tongue of the insect is sometimes held fast. The flower exudes a sticky substance by which it cements its pollen to the tongues of bees and butterflies.

There is a beautiful beetle which is usually to be found on this flower—the dogbane beetle, or *Chrysocus auratus,* as brilliant as a jewel in his armour of burnished green. His faithful attendance suggests that he may

DOG BANE

THE BUTTERFLY WEED

do the work of carrying pollen for his flower favourite, but no naturalist has yet shown this to be the case. Here is a clue for the reader to follow, and a chance for original observation and discovery.

CHAPTER V

ORCHIDS

IF the reader so loves the wild flowers that he has accompanied us thus far, and has patience to push on with us along the streams, over the hills, and through the woods, sooner or later we will come upon a treasure new and rare, a tall and stately flower, aloof and haughty, and we will instinctively know that we are in the presence of the flower of flowers, the Orchid.

We will not gather it, for we are not looting the forest of its richest treasures; but we will enjoy it and study it where it grows, and perhaps we will bring one or two friends who will do homage also.

But before we examine our prize as to its construction and habits, its peculiarities, and

its insect friends, let us establish clearly in our minds what is an orchid.

Reviewing hastily what we have learned of plant development, we recall that those plants which were the first to produce flowers far back in prehistoric times were either pollen-bearing or seed-bearing plants: that is to say, diœcious. Later, plants and trees put forth staminate and pistillate flowers, side by side, and hence were monœcious. At length, stamens and pistils approached one another and were found within the corolla of perfect flowers. Only one more move in the same direction was possible: namely, that the stamens and pistils should actually unite and form a single structure, while retaining their separate functions. And this is exactly what happened in the orchid. Here, stamens and pistils are united into a body called the "column." They are welded together, as it were, and have lost all resemblance to the leaves or petals from which some suppose they originally sprang. So complete has been the union that often the two organs are difficult to identify, the stamens being transformed into mere pockets with slits, or boxes with lids, and the stigmas merely adhesive spots upon the column.

We can see in these progressive stages the steps of evolution leading to the highest type of flowers,

beyond which no progress is further possible. The union of stamens and pistils into the column is, then, the distinguishing mark of the orchid; but, in addition to this, we know that all orchids have leaves with parallel veins, and their flowers are so organised as to depend, with rare exceptions, exclusively upon insects for their fertilisation, and, in some cases, upon one insect affinity in particular.

The pollen of the orchid also is different from that of most other plants. It is seldom the dry and powdery substance we are familiar with, but is usually waxy and is often made up into club-shaped masses, or into globules bound together with minute threads.

Now, many people suppose that the orchids are necessarily "air plants" and that they are very tender and costly flowers from the tropics. It is easy to see that these ideas, true to a certain extent, were propagated in close and humid hothouses along with the gaudy exotic orchids flourishing there.

It is true that the tropical conditions favour and breed a very large number of orchids, many of which are, indeed, air-plants; but, on the other hand, there are orchids adapted to every clime and condition, latitude and altitude, making them the most widely distributed family in the floral king-

NATIVE ORCHIDS

dom. They can find sustenance in every kind of soil, or in no soil at all, and we see, therefore, that they possess an adaptability truly marvellous.

Now, we know that adaptability comes through variation, and variation is brought about by cross-fertilisation. So we see that the wide and varied distribution of the orchids is a direct result of their peculiar and determined efforts to have cross-fertilisation, and to be satisfied with nothing else.

It is their creed, their banner under which they have conquered their "place in the sun"—"In hoc signo vinces," might be their motto. And throughout our vast country, from Greenland to Mexico, from flat Cape Cod to lofty Mount Shasta, we find their tiny banners fluttering, to announce their victory in the struggle for existence.

But not very many of them are ours. Of the seven thousand species known to the botanists, only sixty-eight grow in the United States east of the Rocky Mountains, and many of these are so rare, so quaint in form and colour, so like exquisite works of art, that we think of them as Nature's masterpieces of handicraft, her most recondite form of flower designs, her *bibelots*. And as *bibelots* they are sought after and collected and prized with frenzied enthusiasm. Hunters for orchids travel thousands of miles, undergo every hardship, often risk-

ing their lives, in order to gather orchid treasures from the dark green grottoes of tropic forests. Collectors purchase the bulbs at many times their weight in gold. Business men, soldiers, statesmen, give themselves to the cult of the orchid, and we are reminded of the tulip craze of long ago.

We too shall feel some of the same thrill hunting our native orchids, striving to discover specimens of all the species, and learning the habits of each, and the insect guest which forms its *alter ego.*

And since the orchid is as it is, a lovely creation formed, constructed and tinted with the one purpose to attract its affinity, and thus to perpetuate its aristocratic lineage, this flower, more than all others, must be studied in reference to its schemes and mechanisms, its allurements and subterfuges by which its hopes and ambitions are consummated.

Among our native orchids we discover three distinct schemes or mechanisms for accomplishing cross-fertilisation.

In the first, the insect enters by one opening, passes under stigma and anthers and departs by another opening. This is seen in the lady's slippers, or *Cypripediums.*

In the second, the pollen masses fasten themselves upon the head or the tongue of the insect visitor,

as in the fringed orchids, or *Habenaria,* and others.

In the third, the pollen is formed and held in a box, which opens and dusts the insect as he withdraws from the flower, as exemplified in the *pogonias.*

PINK LADY'S SLIPPER; MOCCASIN FLOWER—*Cypripedium acaule* (*May-June*)

This flower seems to like the company of the wild pink azalea, and may, perhaps, win some of the calls from insect guests visiting the latter flowers.

PINK LADY'S SLIPPER

The gay pink pouch of the lady's slipper is an easy mark for the bumblebee, serves him well for a landing-stage, and soon becomes his trap and prison. For the pouch has a slit opening down the middle, whose edges turn inward, and the bee quickly finds his way in, but cannot retreat by the same door.

Though I have often watched many thick patches of the flower, I have never seen the bee alight upon one of them. I have, however, captured a bee (with gloves, be it understood) and placing him on a

flower, have been surprised by the prompt and businesslike way in which he plunged into the opening, as if he made the flower his special home. Then it was amusing to see what struggles he made and what antics he performed in order to get free. He would swing the flower from side to side, and bulge the pouch here and there, almost tearing it to shreds. Then, at length he would calm down, apparently think over the situation, and seem to spy the daylight in a narrow flue above his head and decide that by that road lay his path to liberty.

But our section of the lady's slipper will show that the passageway is partly barred by two impediments. The column bends forward and downward in such a way as to place the stigmatic surface in the narrow opening; and, higher up, two pollen masses grow just where they will nearly close the narrow exit.

Our bee, then, if he has any pollen on his back must rub it upon the stigma, and in any case he must take some from one anther as he squeezes his body painfully out through the opening above. In spite of the discomfort the bee has evidently experienced he repeats it in visits to other flowers, as we know from the number of seed-pods that later in the season we find on a patch of these plants; and seeds can be created in no other way, for the *Cypripedium*

cannot possibly be self-fertilised, and no insect can enter save by the slit in the pouch. The upper openings are defended by the column, and a shield-like prolongation of it—a modified and sterile anther, lying like a shield or valve over the upper part of the pouch, as seen in the sketches.

Notice that the strongest colour and most pronounced guide lines occur at the entrance of the pouch, while the harmonious and subdued colours are reserved for the graceful petals which droop and float and twist above and around like a quaint head-dress.

The pollen of the *Cypripedium* is a pulpy mass, which adheres like a plaster to the back of the bee; the stigma bears teeth like a comb, to scrape off what it can of the pollen which a bee may have brought from another flower.

All the other *Cypripediums* have their pouches more inflated and exhibit a circular opening with incurved edges in place of the long, concealed slit of the *acaule*.

Showy Lady's Slipper—*Cypripedium hirsutum*
June-July

This is the most stately and gorgeous of them all. Standing three feet high, with two, three, or four blossoms on a stem, it bears floating streamers

of pure white and thrusts forward a white pouch gaily streaked and barred with red. This noble plant seems to require a root-hold in a sphagnum swamp, and there it makes rank growth and splendid blooms by the hundreds. All the *Cypripediums* have the same general construction and exact from their insect guests, in return for their hospitality, the same difficult ceremonies already described.

RAM'S-HEAD LADY'S SLIPPER—*Cypripedium arietinum*
May-August

We must mention this, the rarest of them all, to be found in cold, damp woods from Quebec to Ontario and southward to New York and Minnesota. It receives its name from a curious resemblance it bears to a ram's head, when seen from a certain position.

SMALL WHITE LADY'S SLIPPER—*Cypripedium candidum*
May-June

The petals and sepals of this species are greenish, spotted with madder-purple, as also is the pouch. Though its colour resembles that of the showy lady's slipper, it can always be distinguished from the latter by its modest height, never more than one foot, its solitary blossom, and its two winged petals,

one on either side, wavy and twisted. It grows in bogs and meadows from New Jersey to Minnesota, Kentucky, and Missouri.

LARGE YELLOW LADY'S SLIPPER—*Cypripedium parviflorum*
SMALLER YELLOW LADY'S SLIPPER—*Cypripedium parviflorum, var. pubescens* (*May-July*)

Two varieties of the same species, closely resembling each other, and found widely distributed throughout our range. Between the Cypripedium and other orchids we find no transitional forms; hence Darwin has been led to suppose that some sweeping cataclysm has destroyed the connecting links.

SHOWY ORCHID—*Orchis spectabilis*
April-June

The next scheme of cross-fertilisation is found in this orchid, which is the first of the family to bloom in our northern regions. It seems like a little model of a larger plant, made in fragile porcelain or bisque, so firm and crisp it rises from the ground of rich, moist woods. Two leaves first appear; then between them a spike from five to ten inches tall with a few flowers accompanied by pointed bracts. The flower—there are five or six on a stem—has a purple hood or cowl, overhanging a white bib, or lip, and shelters an erect, white col-

umn which has been aptly styled "the preacher in the pulpit." At the foot of the column (not a pillar of the church) a small opening gives access to the spur below where nectar is concealed.

On the column, just above the nectar-well, the adhesive stigmatic surface is found; and above this again, two curving pollen-pockets. The pollen in them consists of two club-shaped masses, terminating below in round, adhesive discs; and these discs appear as two round dots above the nectar-well, just where they will act as buffers to the head of an arriving bee, though they are slightly protected by an exceedingly thin and fragile membrane that tears at a touch.

SHOWY ORCHID

The mechanism of this orchid, and its workings, are already fairly clear. The bee arrives on the white lip and, thrusting his tongue down the well in search of nectar, rams his head against the two adhesive discs, tearing their membranous covering, and then cements upon his brow two pollen clubs which he withdraws from their pockets, and which

he bears away like two horns, erect upon his head.

But what will happen, supposing that he visits another flower, with his horns in this erect position? They cannot strike the stigma, for it is too low. They must strike other pollen pockets, and the flowers remain unfertilised. But, curiously enough, the pollen masses do not remain erect. As soon as they are out of their pockets and firmly on the bee, they both wilt a trifle, and droop forward, so that they will exactly hit the desired mark—the stigma of the next flower. The reader may test this for himself by thrusting the point of a pencil into a flower, withdrawing the pollen clubs, and observing how quickly they droop forward, as if taking aim at their target.

SHOWY ORCHID

The blossom seems clearly adapted to fit the head of a bee, and the nectary is about the length of a bumblebee's tongue. It is the queen bumblebee (*Bombus Americanorum*) who pays the most frequent calls, though occasional butterflies are not excluded.

ROUND-LEAVED ORCHIS—*Orchis rotundifolia*
June-July

This is the only other species of the *Orchis* genus in our part of America, and is much rarer than the *spectabilis*. Its mechanism and procedure are precisely like those of its sister-flower.

THE HABENARIAS

These have learned the advantages of collectivism. No one would ever speak of them as "socialists" but would say, rather, that they assemble in aristocratic and exclusive clubs, and thus are imposing and effective. Their tapering spikes of flowers, of white, or purple, or gold, are dignified and impressive, and each flower face bears the stamp of personality. It must be a bold insect who dares to interview them without an introduction. The flowers play odd pranks upon their callers, generally fastening upon head or eyes or tongue of each insect a club of pollen, which shortly thereafter withers and droops forward.

We wish to get a clear idea of the construction and customary conduct of these flowers, so will gather and examine a specimen of the most common and the easiest to find in wet, open meadows.

SMALLER PURPLE FRINGED ORCHIS—*Habenaria psycodes*
July-August

From a tubercled root rises a stem about 18 inches high, bearing at intervals three or four clasping leaves and numerous bracts. At the summit is the flower racemo, 2 to 4 inches in length—a dense flower cluster of purplish-pink blossoms, $\frac{1}{3}$ to $\frac{1}{2}$ inch wide. There is a long ovary; three roundish sepals, the upper forming a hood; and three petals, the lower forming the lip. These petals are so fringed and slashed that they give each flower the droll semblance of a face with perky side-whiskers, combed in the height of the fashion.

In the heart of the flower is a minute opening just large enough to allow a moth's tongue to reach the nectar in the deep spur below; and, guarding this entrance on either hand, lie two parallel pollen sacs, containing clubs of pollen. The stigmatic surface is immediately above the opening and between the pollen pockets. The mechanism is now in working order and requires only the proper insect to set it in motion.

PURPLE FRINGED ORCHID

HABENARIA ORBICULATA AND CLEAR-WING MOTH

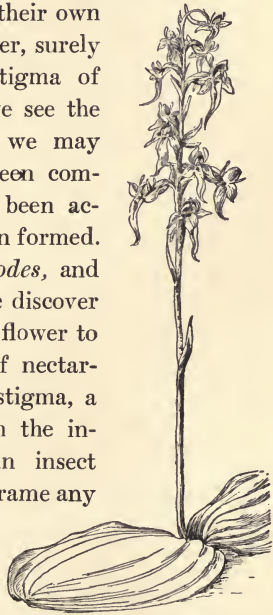
This insect is preferably one of the small, day-sphynx moths, for no bees nor beetles can reach the nectar. Suppose, then, a sphynx comes to sip and, humming and hovering on the wing, he thrusts his tongue into the nectary. He will be pretty sure in so doing to touch one of the glands of a pollen club and, retreating, to pull the pollen mass out of its pocket and carry it away on his tongue.

For a moment the club stands out stiff, at right angles to the tongue, but straightway it curves forward and downward; and by the time that our moth has found another nectar-well, the stigma above that well will receive the touch of the pollen—a thing that could not happen if the club retained its erect position.

The reader can "play the moth" to the fringed orchid, using a pencil-point for proboscis, withdraw the pollen clubs and watch them promptly wilt and

droop, in anticipation of their work in the next flower, and thus by actual experiment verify the practicability of the mechanism and its successful working.

It is not necessary to point out that this mechanism precludes self-fertilisation and insures cross-fertilisation. It is self-evident that the pollen masses are drawn away from their own stigma, and will, sooner or later, surely come in contact with the stigma of another flower. Wherever we see the stately *Habenaria* growing, we may be sure that the cycle has been completed, cross-fertilisation has been accomplished, and seeds have been formed. But in the *Habenaria psychodes,* and in all others of the orchids, we discover such a nice adjustment of the flower to its affinity in colour, depth of nectar-well, position of pollen, and stigma, a dependence so complete upon the instincts and habits of certain insect friends, that we are unable to frame any theory which shall explain how the complex arrangement came to be, and can merely marvel and admire.



BROAD LEAVED HABENARIA

All the orchids of the *Habenaria* genus are similar to the purple fringed orchid in their arrangement, structure, and the way they have of fastening pollen upon their insect callers. Certain very slight variations, which do not modify the procedure, should, however, be pointed out.

LARGE ROUND-LEAVED ORCHIS—*Habenaria orbiculata*
July-August

Remarkable for its two huge, round leaves, lying flat upon the ground, and its very deep nectar-well, a spur 1½ inches long, whose depths the night-moths and butterflies alone can reach and drain.

In anticipation of such visits the flower places its pollen-pockets divergently, with adhesive glands toward each other, and so spaced as to just catch the head of a moth between them. Consequently, a moth who abandons all discretion and ventures so deep into the flower will carry away two clubs of pollen, glued to his head or his eyes, as we see in the sketches on page 142.

HOOKER'S ORCHIS—*Habenaria Hookeriana*
June-Sept.

An orchid resembling the former, but considerably smaller. The pollen masses are attached to

their adhesive glands by a kind of hinge, which allows or compels them, as soon as out of their pockets to bend downward and forward, so as to strike with certainty the stigma of the next flower.

TALL WHITE BOG ORCHIS—*Habenaria dilatata*
May-August

A strictly northern orchid, being found in Maine, the White and Green Mountains, and even braving the rigours of the Iceland climate. It is pure white in colour, and has the peculiarity that the pollen glands are shaped like the sole of a shoe, and also, when the pollen clubs are removed from their sacs, they do not bend downward, because they are already in a position upon the insect such as conveniently to touch the next stigma.

TALL LEAFY GREEN ORCHIS—*Habenaria hyperborea*
June-August

While this is similar in most respects to the foregoing orchids, it has this peculiarity: The pollen masses are so loosely contained in the anther sacs that they often fall out in the bud and are found, when the flowers open, to have rolled about loosely and to lie against the stigma.

Thus, as a rare exception, this orchid may be self-

fertilised; but since the pollen glands still retain their adhesiveness, they may sometimes be borne away to the stigma of another flower, and thus cross the life lines and stimulate the seedlings into renewed vitality and resistance.

SMALL GREEN ORCHIS; TUBERCLED ORCHIS—*Habenaria flava*
June-July

TUBERCLED ORCHID

An inconspicuous little orchid found in wet meadows from Ontario to Minnesota, and southward to Louisiana and Florida. Each little blossom is but a quarter of an inch high and wide, and its distinguishing feature can be discovered only by means of a strong glass. This is a little protuberance or tubercle growing up in the middle of the lower lip. I believe we owe to Mr. Gibson the explanation of this excrescence, which he supposes to be intended to compel an insect to approach the nectar-well from the right or the left side, and thus to make sure that his tongue shall touch one or the other gland and pull away a mass of pollen.

RAGGED FRINGED ORCHIS—*Habenaria lacera*
July-August

An orchid having about the same range as the preceding one, and also with a contrivance for diverting the tongue of the insect to the right side or to the left. A projection, again, divides the pathway to the nectar-store, but this time from above.

The column bears stigma and anther sacs in their usual place, above the opening to the nectar-well, but just here it bends down into a little beak, or spur, thus dividing the opening into two little gates. A moth's tongue must, then, pass to the right or to the left of the centre, and in so doing must touch and remove a pollen gland.

RATTLESNAKE PLANTAIN—*Epipactis*
July-August

This modest little plant has put off the splendours of the orchid, and even disguises the veining of its leaves under a pattern of white lace, as if it would shun its relatives by masquerading. I was greatly surprised to know that this "plantain" was an orchid, and to learn that it had an ingenious mechanism resembling that of the *Habenarias*. The flowers are very minute, but will yield their secrets to close study under a magnifying-glass.

They grow in small, spiral racemes, and we notice that the lower flowers on the spike are wider open than those higher up. The reason for this will be plain when we examine sections of the flowers. In the upper and partly open flower the column is curved downward and the lower lip curved upward, so that the pollen masses, four in number, come just where the passage leads to the interior of the flower and the nectar it contains.

In the older flowers, growing farther down, the pollen has been taken, the lip has uncurled downward, and the column has straightened up, so as to expose its stigmatic surface, beneath, to the pollen which a bee may bring.

The cycle of action is as follows: From the upper blossoms the bee carries away some pollen-masses upon his tongue, and these, as usual, wilt and incline forward. From this flower-spike the bee sweeps downward to the lower flowers of a neighbouring

RATTLESNAKE PLANTAIN

spike, and finds the portal open wide. Opposite him, within, stands the stigma, ready to receive and hold any pollen that comes that way.

Thus there is a shifting of pollen from flower to flower, and thus it is that the modest little plants make their many seeds, and form large colonies, matting the cool pine forest far and wide.

There are three species of the *Epipactis* in our region—the *repens, pubescens,* and *decipiens,* but their modes of procuring cross-fertilisation are identical.

Lady's Tresses—*Gyrostachys*
September

The last orchids of the year are the lady's tresses, whose slender and graceful spires adorn many a field and roadside. We have seven species growing in our northern and eastern region, all of whom have one mode of procuring cross-fertilisation, a mode closely resembling that of the rattlesnake plantain. We find the same mechanism of the column, bent downward in the newly opened flowers, rising as time goes on, to expose its stigmatic surface to the touch of the pollen.

LADIES' TRESSES

But in the *Gyrostachys* the pollen is held between the forked, or two-toothed, beak which terminates the column, in a kind of sugar-tongs contrivance which comes away with its contents of pollen-masses upon the slightest touch of the insect.

The first sketch shows a young flower with the beak in place on the column. The second shows the beak or tongs split open and discharging the pollen. The third shows an older flower, whence pollen has been removed and where the column has risen, exposing its stigmatic surface to the approach of the visitor, often a bumblebee.

LADIES' TRESSES

The reader will understand with what precision the mechanism works, sending away its own charge of pollen, then readjusting itself to receive some pollen from another flower.

Certain orchids, as we have said, enclose their pollen in little boxes which open only as the insect backs out of the flower, and snap shut again. The contrivance reminds us somewhat of the mechanism on the stigma of the iris, a lip which acts as a lid to protect it from the touch of its own pollen, or as a scoop to scrape up pollen brought from a distant source. But the places of stamens and stigma are

interchanged—as we see in the sectional view of the rose pogonia.

Rose Pogonia; Snake-mouth Pogonia—*Pogonia ophioglossoides* (*July*)

This is a very common orchid, to be found in meadows and swamps from Canada to Florida, and as far westward as Kansas. And, strange to say, from thence it seems to jump across mountains and sea, to flourish in Japan.

The name "snake-mouth" very well describes the shape of this flower, a veritable mouth formed by six petals and sepals, the lower one, forming the lip or chin, bearing a mat of strongly coloured tufts on which the bee may travel to the nectary.

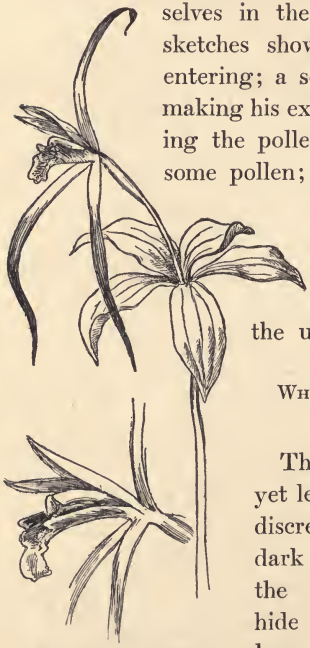
SNAKE-MOUTH POGONIA

The column, projecting horizontally forward, bears the stigma on its under side, and the anther sacs on its forward end. But the sacs are covered by a spring lid holding in the pollen masses securely till the proper time comes.

The bee can reach the nectar unimpeded, and if

he brings pollen on his back he can place it upon the stigma where it will adhere, but only as he retreats will he open the lid of the pollen-box and carry away to another flower some of its contents.

Other pogonias have the same spring-lids upon their anthers, and, consequently, comport themselves in the manner described. Our sketches show a flower with the bee entering; a sectional view with the bee making his exit, and unconsciously opening the pollen box and carrying away some pollen; and a section of a flower where the bee is entering and is rubbing off some of his pollen-burden upon the stigmatic surface on the under side of the column.



WHORLED POGONIA

WHORLED POGONIA—*Pogonia verticillata* (*May-June*)

This orchid is quite common, yet less easy to find, because its discreet colours of green and dark purplish brown melt into the surroundings and almost hide it from view. Its three long, dark streamers give it an

odd appearance, but the lip, frilled and blotched, is very beautiful. The spring mechanism of the pollen-box is precisely like that of the previous one.

ARETHUSA—*Arethusa bulbosa*
May-June

This is probably the most beautiful of our native orchids, though Arethusa and Calypso might easily tie one another in a beauty contest. The stem grows from a small bulbous root to a height of five to ten inches, with a few linear leaves, and bears at its summit the solitary, nodding flower of a lovely rose-purple hue. Above the throat of the flower are three banners and a hood of purple; below it, a lip drooping and blotched with purple and yellow.

Under the hood the column rises and curves forward and downward, guarding the approach to the deep nectar-well. The stigmatic surface is beneath the curved column; and the anther sac at the outer end retains the four pollen masses by a little spring cap.

The mechanism of Arethusa operates in exactly the same manner as that of the Pogonias, and needs no further description.

CORAL ROOT—*Corallorrhiza*
May-July-Sept.

The coral roots, of which we possess three species, are dull, inconspicuous and not prepossessing. The fact that they are orchids lends them a certain interest, and their mechanism is worth studying. But since both their construction and their operation are practically identical with the two just described, the student needs no further suggestions to guide his investigations.

LILY-LEAVED TWAYBLADES—*Liparis lilifolia*
June-July

A quaint little orchid, rarely seen hereabouts, though it is listed in the botanies as rather common

LARGER TWAYBLADES

in New England. I was so fortunate as to discover and to transplant close to my study door two specimens which have lived and flowered six successive seasons, but without ever once making seeds or increasing in numbers. I have tried to cross-fertilise them artificially, but without success. They

unfold two ovate leaves, resembling those of the lily-of-the-valley, and send up from between them a flower-stalk about six inches tall, upon which cluster a dozen or more blossoms, looking like a small swarm of mosquitoes. This effect is due to the slender, spreading petals and sepals, and a diaphanous and smoke-tinted lip, like a mosquito's wing. This lip has a groove along its centre, leading to the nectar-well, over whose opening the green column rises in the form of a beak, cupped with a pointed lid. In the upper end of the column are two depressions containing the pollen masses, two in each.

I have never seen any insect at work on this flower, and I have observed that the caps over the pollen are never disturbed. Nor has any scientific observer, so far as I have read, been able to tell us of these visits. But the mechanism is practically identical with those already described, and its working is bound to be much the same.

Here, however, is a flower which presents to the student a rare opportunity for original investigation, and a subject for an essay which shall add distinctly to our fund of knowledge.

There is another of our native orchids, the grass pink, or *Calopogon,* which is even more mysterious, in that its mechanism is apparently simple, yet its workings are not understood.

It is the rule, nearly absolute, among our native orchids, that the ovary is twisted through 180 degrees and we find the external ribs or ridges describing spirals about them. The result of this twist is that almost all the orchid flowers are actually inverted. Their upper petals have become the lower lips, and for so many centuries have served as lips and landing-stages for insects that these misplaced petals have taken on colours and form, channels and tufty beards, to fit them for the work they have to perform.

But the Calopogon and the Habenaria niva have not thus turned their heads upside down, and in these two we may, perhaps, find the earliest and the latest development of our orchids.

Southern White Small Orchis—*Habenaria nivea*

This rare and inconspicuous little orchid has a remarkable and exceptional feature—its ovary is seen to be normal and the ridges upon its surface straight and parallel. The spur, where nectar is secreted, consequently lies above the ovary; and the petal which usually forms the lip, here waves as a banner above the nectar-well.

In Mr. Gibson's book on the orchids I read of this flower and the insect's visit to it:

"Perhaps there are some odd manners left over

from the Tertiary age, when plants that are now found only in fossil form on the pine barrens were the progenitors of the modern orchid. Possibly the straight ovary is a relic of an earlier, simpler form of orchid, and the twisted ovary a concession to the manners of insects of later days, and possibly it is because the insects are not well adapted to the over-reaching spur, that the plant is so rare."

This southern specimen, it will be noted, has no beard nor markings upon either the upper or the lower petal, so that neither the one nor the other may be called "the lip."

Let us now examine the northern orchid, the other exception to the rule above stated.

Grass Pink—*Calopogon pulchellus*
July

An orchid very common in bogs and moist places throughout our region, with a straight ovary, and the column curving *downward* with the stigma on the upper surface and the lidded anther-cells underneath. But in the *Calopogon* the *upper* petal displays a tufty beard of yellow and magenta-crimson—showing, in spite

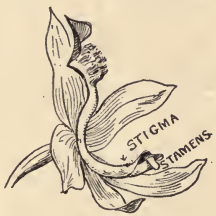


DIAGRAM OF CALOPOGON

of its erect position, that it has been a lip, a path-finder and a landing-stage for insects, and that it still has work to do in that line.

It seems as if the Calopogon had gone through all the stages of development, twisting up the ovary, working out its mechanism for cross-fertilisation, assuming pleasing fragrance and alluring colour, shaping its stigma and pollen, its column and lip to conform to certain insect visitors; then, by a streak of atavism, a trick well known to breeders of plants and animals, had reverted to a primitive type, had straightened out its ovary, and had turned its life topsy-turvy.

CALOPOGON

I can liken the Calopogon's story to that of a country lad who had lived many years in the strenuous city, and, returning to country life once more, had found it good. For the Calopogon certainly finds life good, and is immensely successful in the struggle for existence.

Let us see what it does for a living in this reversed position. Gray tells us that "the lip is as if hinged"—and you will have the fact confirmed if you bring a spire home and keep it in water over

night. Though the flowers are not otherwise faded, the lip on the oldest flower, which stood so stiff and erect, will now droop forward, and its gay beard will hide its colours upon the upturned stigma. You will find the same to be true of the lips of older flowers as they grow in the fields. Here, then, is a distinct mechanism, planned to accomplish some purpose in the direction of cross-fertilisation. The change in the lip has modified the flower completely, as seen in the two sketches. A bee approaching the upper blossom will naturally make for the bright spot on the erect lip, and cling fast to the roughened, hairy surface. But where the lip has shut down, the heart of the flower will seem closed, and the bee will alight on the petal which hangs down in the middle, a landing-stage directly under the pollen-sacs.

Here, then, is my explanation of the action of the flower: A bee comes to a mature blossom whose lip is depressed, alights upon the lower petal, which serves as a lip or door-step in this new position, and thrusting his head in under the column where nectar ought to be, he casually knocks off the cap from the pollen-cells and receives a charge of pollen.

He probably goes away from this visit disappointed as to nectar, but seeks a more hospitable flower elsewhere, whose lip is erect. Now, with the pollen upon his back, how can he deposit it on the

upturned stigma? The explanation is that he makes a "bee line" for the brightly coloured lip, grasps it with his claws, and with all his weight pulls it over upon himself and tumbles backward upon the stigma, placing his pollen-charge just where it is most wanted. In an unceremonious way, the pollen has been projected into the heart of the flower, the bee has paid his toll and now is free to wander about and drink all the nectar he can find secreted there.

If the reader wishes to pursue the subject still further, and investigate the doings of the foreign orchids, he will unearth mysteries still more romantic and extraordinary than any we have thus far unveiled. He will learn of an orchid, the *Pasquira fragrens,* which actually shoots its pollen mass, exactly as a submarine shoots its torpedo. Then he will come upon the story of a *Catteleya* which, for nine successive years, produced pistillate flowers, to the despair of its owner, till a time came when it at last sent up a pollen-bearing flower.

Even a legend is current of a vampire orchid which deadened the senses of its finder, in order to suck the blood from his veins. The romance of the lost orchid, too, is full of thrills. A few specimens were owned and treasured, but they gradually dwindled and died away and their existence became

but a memory, till the British army forced its way into the closed boundaries of Thibet, and restored the lost orchid to the world.

The Flower Kingdom is still full of surprises, and its mysteries have not yet been unravelled. In the foregoing pages we have shown the way, and we hope that the student will be inspired to follow the trail. For every excursion will bring some new secret to light, and many familiar flowers will reveal a life history which it has been hiding for centuries in its heart.

CHAPTER VI

THE WIND AND THE FLOWERS

THE reader may think it strange and inconsistent for us to turn from our studies of the most complex, interesting, and highly developed of the flowers, and give our attention to the simple, primitive, and lowly ones, which trust their lives and destinies to the fickle favours of the wind.

It was only after my interest and enthusiasm were aroused by the very showy flowers that I became curious to solve the mysteries of their humble relatives, who had no colour, nectar, nor perfume to offer.

Where these charms are lacking in flowers, insects are apt to pass them by; and we, too, are prone to do the same. But once our interest is aroused, we are sure to seek out the mysteries of such humble and inconspicuous flowers as those of the trees, grasses, cereals and rank weeds. In fact, we scarcely suspect that some of these bear any flowers; yet flowers they have, such as they are, and in great abundance. For flowers are known by what they accomplish; and these inconspicuous ones give seedling forests to clothe barren hillsides, myriad grasses and grain for our fields, and hosts of weeds to teach us patience in our gardens.

Wind fertilisation of the flowers may be considered as a crude and primitive plan, for it was certainly in operation before insects came to do the work, and the two schemes suggest a comparison with Man's work of early days and now. As wind and water did the work of carrying pollen, so men used wind and water to do their hardest tasks, of grinding, spinning and sawing. Later men tamed beasts of burden, and flowers ensnared their insects

and trained them to fetch and carry, to work and toil in return for the meagre compensation of food. We have seen how ingeniously and completely the flowers were the taskmasters. Let us now see how trees and plants have harnessed the wind, and make use of it to carry pollen. This pollen is extremely fine and light, so as to fly far, and also most abundant, in order to allow for great waste while a small proportion reaches the desired goal.

The pollen of pine-trees sometimes falls in such quantities as to be taken as a shower of sulphur or "yellow snow." It has been caught by a kite flying 1200 feet in the air, and has been found upon the snows as high in the Alps. Out at sea, some 300 miles from land, the sailors sometimes sweep it from their ship's deck in bucketfuls. But this gigantic swarm of pollen grains is set free from the trees in the spring, before leaves have unfolded to impede it in its flight. It is produced by stamens somewhat similar to those of other flowers, though clustered together in tassels, or cones, forming monœcious or diœcious flowers.

The pistillate flowers to which the pollen is consigned are of two very distinct forms: those having no stigma, but the seed exposed, and hence called naked, seeded, or "gymnospermous," such as the pines, larches and firs; and those having enormous

stigmas but seeds enclosed in a case or pericarp, and hence called "angiospermous" flowers, as in the birch, cat-tail, dock and others.

There is a lofty independence and majestic optimism about the great pines which fling opulently their pollen to the breeze, hundreds of feet above the loftiest flights of earth-born insects. Let us see how the pollen sometimes reaches its destination.

PINE CONE
(a) Staminate Form; (b) Anther; (c) Pollen Grain

In the spring the pines put forth new growth, and at the tips of the tender branches appear little cones—shown in the two sketches. The staminate cones are the smaller and more numerous. The overlapping scales of these cones are each a stamen,

with two anther sacs on their lower sides. On their upper sides are often hollows, or depressions, to catch the pollen and to give it to the wind uniformly. The pollen grains of the pine, as they ripen, develop little wings—shown in the drawing—which help to sustain them on the long and hazardous flight. Most of them come to grief on the voyage; only an infinitesimal proportion reach port.

PINE CONE
(a) Pistillate Form; (b) Ovule; (c) Scale with Seed; (d) Seed

They remind me of rays of a wireless message—shot into the air and scattering in space in every direction, only one small impulse reaching the receiving antennæ and carrying the desired message.

The receiving station, or pistillate cone, stands erect, its scales open, forming numerous cavities in

which the pollen may lodge like yellow snow-drifts —as seen in the sectional drawing. On the under side of each scale, near the base, two little ovules are waiting. They have no pistils but, instead, small openings leading within. At each opening is a little drop of moisture which catches and holds the pollen grains brought by the wind. The fluid gradually dries up, drawing the pollen grains within the pollen-chambers to the ovule, which thus is fertilised. Then the scales of the cone close, and the whole cone droops upon its stem as a protection against the rain. It increases enormously in size while the seeds are developing within. A year and a half pass by before the scales open again, but this time to release a flight of little winged seeds, which go whirling away to grow into new trees, if they can.*

Angiospermous flowers, whose ovules are concealed, necessarily put forth enormous stigmas to catch the flying pollen.

The staminate and pistillate flowers are sometimes clustered into separate catkins, as in the hazel and beech.

The sketch of a chestnut bough in bloom shows

* See *Contribution to Knowledge of Life History of the Pine* by Margaret C. Ferguson, in Bulletin of Washington Academy of Sciences, 1906.

us how the pollen is made upon pretty tassels and is caught by scaly stigmas. Some plants, such as

CHESTNUT

the box-elder, dock and sorrel, bear pendulous flowers. Others, again, are distinguished by their long, loose stamens.

In the sketch of a single floret of the timothy, remark the long, branching pistil and the curious, dangling stamens. There are two anther-cells, like two bean-pods, growing back to back and splitting open at the lower end to set the pollen free. These stamens are all packed closely into the floret till a warm, dry,

FLORET OF TIMOTHY

breezy day comes, when they burst out of bounds, dangle at the ends of their hairlike filaments, and swing and sway gaily, scattering their pollen like maskers throwing confetti; and, like confetti, their pollen floats away to their neighbours.

Grasses bear perfect flowers but hops are monœcious. The two sketches show branches of hop vines taken from different plants, and exhibiting the enlarged staminate flower with its umbrella-like calyx and pendulous stamens symmetrically arranged. In the pistillate flower we see the long, shaggy pistils protruding from beneath the scales.

HOP VINE
Staminate Flowers

When I was a boy and used to help in gathering the hops for our home-made yeast, I imagined that the bitter, yellow powder concealed between the scales was the pollen; but I have learned that I was in error. Botanists do not seem to know what is the use of this powder, but brewers know it is valuable in flavouring their beer.

HOP VINE
Pistillate flowers

Our billion-dollar corn crop every season hangs for a while suspended on these frail, impalpable

CORN

(a) Plant in full. (b) Staminate Tassel. (c) Flower. (d) Pistillate Flower Cluster. (e) Silk. (f) Stigma.

threads, and flies at hazard on the wind. Corn, as we know, forms tassels of staminate flowers at the apex of each stalk, and "ears" of pistillate flowers below. Staminate flowers may be seen in the upper sketch; and, below, a single flower greatly enlarged. A tassel discharges great quantities of pollen, sending it forth, not all at once, but day after day, as the stamens progressively mature; and this pollen sweeps through the corn patch and lodges here and there upon the "silk."

For each corn silk is the stigma of a single little

floret; and every floret on the cob has its long strand, reaching out for life—as we see in the lower drawing, where silks are separated to show their attachments. A single kernel is shown, separately, and the stigmatic termination of a pistil, greatly enlarged. Every strand of silk must get its pollen or the corresponding kernel of corn will fail to perfect.

The value of cross-fertilisation is beautifully illustrated in the case of corn, for, if a stalk grows solitary and removed from reach of pollen from neighbours, it produces either no grains at all, or a few due to self-fertilisation which are poor and imperfect.

RAGWEED

Other plants with long, swinging stamens are sedges, reeds, hemp, litorella, water-starwort, early meadow-rue.

The common ragweed grows its pistillate flowers in the axils of the leaves, and its staminate flowers in the tassel above, as shown in the drawing. The anthers, however, do not hang loosely, but are packed into an

umbrella-shaped calyx, like berries in a basket.

Some plants, fertilised by the wind, perfect their pistils before the stamens, as we saw in the case of the two plantains. In the sketch are seen two florets of the common plantain, the upper in the pistillate and the lower in the staminate stage.

COMMON PLANTAIN
Floret above with pistil
Floret below shedding pollen

BURR-REED

Many flowers grow in stiff spikes with the staminate above and the pistillate below. The cat-tail is a well-known type of this arrangement. The burr-reed shown in the drawing is a singularly decorative plant of like habit.

Finally, we come to a class of flowers, fertilised by the wind, which discharge their pollen into the air explosively. It is said that the mulberry, the pelletory, and the nettle are so organised. I have read that between five and six o'clock of a dry morning one

may see little puffs of pollen rising above the nettle plants like a faint mist; but, though I have been well stung by this plant in the interests of science, I myself have never seen the pyrotechnics. The flowers are of exceedingly simple construction, consisting, as we see in the detail sketches, of a calyx and stigma in the one case, and of a calyx and four spreading stamens in the other. But before the staminate flower opens, the filaments are curved inward and the anthers are turned downward, as shown in the sectional sketch of a closed bud. Herein lies the secret of the explosive pollen. For, when the bud opens at dawn, these curved filaments are released and straighten themselves out with sudden force, and thus throw the pollen to the morning breeze.

NETTLE

CHAPTER VII

SELF-FERTILISED FLOWERS

DEFINITION and description of a thing implies the existence of its opposite. There are exceptions to every rule, and this applies to the cross-fertilisation of flowers. All flowers are not always and invariably cross-fertilised. Many of them at times are self-fertilised. In fact, the rule is that no flower can live upon self-fertilisation alone, but must occasionally have its pollen crossed with that of another flower of the same species.

It is probable that the first *perfect* flowers were entirely self-fertilised, and as the struggle for existence became more and more fierce, they devised for themselves means that should better fit their race to conquer.

Let us see what flowers may or may not be self-fertilised. In the first place, we may cut out all our orchids, save one. They, with the exception

of the tall leafy green orchis, are so organised as completely to prohibit self-fertilisation.

The complicated mechanism of the milkweed rigidly exacts cross-fertilisation; and we know that the clover is as firm in the matter—as was proved by the experience of the farmers of Australia, who could get no clover to make seed till bumblebees were imported.

The jewel-weed, iris, trumpet-vine, and monkey-flower should be crossed off, since their mechanisms also forbid self-fertilisation. Then, the many flowers whose stamens shed pollen and wither before the stigma is ripe, of which the wild geranium is a type, are practically secure against self-fertilisation; for, to all intents and purposes, they are staminate flowers at one stage and pistillate at another.

The flowers belonging to the classes so far mentioned are perpetuated through cross-fertilisation only.

After them come many flowers which are less strict in their habits, and which permit or even arrange for self-fertilisation, as a last resort, to avoid extermination.

In the mountain laurel flower it might easily happen that a few grains of pollen should be thrown upon the stigma, though as a rule the body of the moth visiting the flower is likely to form a shield

and a target to receive the charge and bear it away.

Among flowers of the Lily family stamens grown old often incline inward and rub the stigma, giving up any pollen they may yet retain. The trillium might easily be self-fertilised, and the early dog-tooth violet usually is so. The wide open flowers of the Rose family offer little barrier to stop pollen from passing from stamens to stigma; hence, the purple-flowering Virginia raspberry is frequently self-fertilised, as is also the high blackberry. Following we give a list of flowers where the same is possible or likely to occur:

Pitcher-plant
Turtle-head
Nicotina
White water-lily
Lady's-smock, or Cuckoo-flower
Bulbous or Spring Cress
Meadow-sweet
Enchanter's Nightshade
Flowering Dogwood
Toadflax
Hound's Tongue
Sweet William
Downy Phlox
Ground or Moss Pink

Besides these, there are certain flowers which, though usually cross-fertilised, yet have certain tricks and schemes to fertilise themselves. Here we find the inventive ingenuity of flowers manifested in a new direction, and for an unexpected purpose.

Some flowers with long, tubular corollas and persistent pistils have a curious way of withering, separating from the calyx and slipping down the styles till they hang, loosely swinging by the stigma. I have often seen faded azalea, honeysuckle and convolvulus flowers so dangling, and wondered why they did so, till I heard the explanation given that here was a means for bringing loose, stray pollen grains, which might accidentally remain in the tube, down to the stigma, where it might be greatly needed. If this be the correct solution of the matter, we here have a very curious mechanism to accomplish self-fertilisation.

In the Campanulas and Gentians the relative positions of stamens and stigmas favour cross-fertilisation, but in case the customary visitor fails to arrive with the desired cargo of pollen the stigmas will split downward more and, curving outward, come into contact with the anthers, or with pollen collected in the corolla.

ROUND-LEAVED MALLOW—*Malva rotundifolia*

MALLOW

This attracts few insects by its small pale flowers, and consequently is able to fertilise its own stigmas in the following curious way.

In the centre of the flower rises a stalk, close about which grow numerous anthers. Above them springs a cluster of styles, each bearing a stigma. If an insect fertilises these advancing stigmas, nothing more is required. But, this failing, the styles curl downward like the tentacle of a minute octopus, curve and twist around the stamen-cluster, absorb pollen from them, and are fertilised.

The barberry, whose exquisite mechanism for cross-fertilisation we described in full, is not too sensitive and shrinking to avoid self-fertilisation. In fact, it is quite capable of this act, for the stigmatic surface is just on the edge of the cap of the pistil, and the stamens when they dry and curve forward in the later stages of the flower are just long enough to touch this stigmatic edge with any pollen remaining.

BARBERRY

But self-fertilisation is not always merely a resource and a forlorn hope

in case the pollen-laden Argosies have failed to come to port.

Several of the Rose family are regularly self-fertilised—the hardhack or steeple-bush, the wild red raspberry, agrimony, and June-berry, for example.

Though the Composite family has developed a clever piston arrangement for delivering its pollen, and bidding for cross-fertilisation, yet the following members of the family are commonly self-fertilised and flourish amazingly upon it: The starwort, asters, common daisy, larger daisy, fleabane, larger burr marigold, tall sunflower, ox-eye, cone-flower, common dandelion, sow-thistle, and others.

It is easy to see that the Pulse family, in whose flowers the stamens and pistils are closely packed together like shipwrecked mariners in a life-boat, might develop their stigmas in a mass of home-made pollen, if that were not removed. This may happen in the beach pea, the cow-vetch, and the peas and beans of the garden. Here we see a reason why our peas and beans always "come true to name," and Mr. Burbank has suceeded in creating new varieties only by artificially crossing their pollen.

Whitlow grass, wood-anemone, shepherd's-purse,

the St. John's-worts, Depford pink, and smaller Solomon's seal are generally, but not always, self-fertilised.

The smallest flowering plant in the world, the duckweed, or *Lemna,* follows the same plan, and is most interesting to study under the microscope. You will find in stagnant pools myriads of these tiny plants, forming a green crust upon the surface. The plant, consisting of one or two leaves, about one-fourth of an inch in length and a little less in width, floats upon the water, sending down one or several threadlike roots, an inch long, each terminated with a pointed sheath. The plant grows by lateral branching, and toward autumn the leaves separate from each other, form separate plants and sink to the bottom of the pool, to rise again in the spring, larger and more mature. In the summer the flowers, such as they are, appear upon the surface or at the edge of the plant. They are monœcious flowers, reduced to the lowest terms, for they consist of one or two stamens and one pistil, of the form shown in the sketch.

DUCKWEED

These organs are in such close proximity that they fertilise each other, and produce true seeds.

Now, from this humblest of flowering plants we may deduce two facts: first, self-fertilisation has been so successful that the duck-weed survives, and has spread out all over the world; second, the plant has not been able to develop and raise itself to a higher form of life.

F. Ludwig expresses the opinion that duckweed is adapted for fertilisation by insects which live on the water, and undoubtedly there is no barrier to prevent it. In fact, insects may occasionally have crossed the pollen of some plants long ago, thus causing slight variations which are classified in four distinct species. In spite of this, however, the duck-weed stands as an example of what self-fertilisation can and cannot accomplish.

So far as we know there is but one plant or flower which is self-fertilised by an insect: namely, the Spanish bayonet—a native of Mexico but acclimatised in our Northern States.

SPANISH BAYONET—*Yucca*
June-July

This is a very handsome and decorative plant, familiar in our gardens. From a thick cluster of stiff, divergent leaves, each armed with a cruelly sharp point, rises a flower-spike three to five feet tall, covered with ivory-white blossoms resembling

tulips in form, but hanging gracefully downward. Each flower has six white sepals and petals, forming the bell, a long pistil exactly the shape of a bottle with an opening down through the neck leading to the ovary within, and six stamens set about the pistil, but all of them much too short to scatter pollen upon its tip, nor would the pollen take effect if placed there.

It is the exceptional and extraordinary feature that its pollen must be forced down the neck of the bottle and into the ovary, in order to vivify the ovules within. No happy accident will do this; and there is only one insect that will. It is a moth known as the *Pronuba Yuccasella,* the only moth I know of which is provided with a pair of jaws for the work. From "The Moth Book" I copy the following description of the creature and its conduct:

"No discovery in recent years has been more interesting to students of insect and plant life than that which was made in 1872 by Professor Riley, of the intimate relationship which subsists between the beautiful plant known as Yucca, and the genus of moths to which the present species belongs. It has been ascertained that the fructification of the various species of Yucca is almost absolutely dependent upon the agency of the female moth; and,

THE YUCCA FLOWER AND ITS MOTH

strangely enough, it has also been ascertained that the pollenation of the flower is not the result of accidental attrition of the wings and other organs of the insect, when engaged in seeking nectar in the flower, and when engaged in laying her eggs, but that she deliberately collects the pollen with her mouth, which is peculiarly modified to enable her to do this, and then applies the pollen to the stigma with infinitely better care than it could be done by the most skilful horticulturist, using the most delicate human appliances."

YUCCA AND MOTH

The moth is shown in our sketch at work upon the stamens and the pistil. Now, why should the *Pronuba* exert herself thus, to do a good turn for the Yucca? Where is the reciprocity in the transaction? When we are able to watch the whole transaction we will see that the moth not only pushes pollen into the upper part of the pistil, but proceeds to bore a hole into the lower part and lay her eggs there. In due time seeds will form and eggs will hatch, and the little larvæ find food

in the capsule just suited to their taste, till they grow large enough and strong enough to go forth and burrow into the ground.

It is, then, to make a home and provide food for her babies that the moth fertilises the Yucca. Where there is no Yucca Moth there are no Yucca seeds formed. In Mexico and other regions where the Yucca is indigenous, the *Pronuba Yuccasella* also is found. In our northern region, till recently, there were no moths and consequently no seeds were set. I read in Mr. Gibson's "Notes" of twenty years ago that the *Pronuba* had not yet arrived in Washington, Connecticut, and Yucca plants then bore no seeds. But since then the moth has evidently come hither, for in 1913 I found a Yucca plant near my home bearing many seed-capsules, and to test their fertility I planted a handful of their seeds and thus have reared a sturdy little colony of Yucca plants, the first of their kind here grown from seed.

The interdependence of flower and moth, this altruism more than human, so exceptional, suggests a path of investigation well worth following. The relations of all insects to all plants have not yet been investigated. We have been fortunate enough to learn of a pair which depends for life, each upon the other. There may be, and probably are, other

similar cases which will be disclosed to the close and sympathetic observer.

The subject of self-fertilisation would not be complete without reference to those flowers which grow expressly to fertilise themselves. There are certain plants so determined to survive, so doubtful of the capacity of their beautiful blossoms to carry along their life history, that they produce also other flowers of a different sort—"resource flowers," or cleistogamous flowers, they are called.

After your sweet violets have ceased to bloom, in July or August, dig up a plant and you will find odd, colourless, formless flowers and seed vessels, just above the ground. The little buds have never opened, but the stigmas have been fertilised and have filled the capsules with countless seeds. A flower and its section are shown in the sketch.

VIOLET

Try uprooting other plants in Nature's garden and, now and again,

POLYGALA

you will discover resource flowers like those of the violet. You will find them on the Polygala, jewel-weed, wood-sorrel, wild bean, frost-weed, Venus's looking-glass, and Whitlow grass. But all the cleistogamous flowers are not subterranean.

The *Dalbardia* is said to fertilise itself in the bud before opening.

Near my gate, under the beech-trees, is a patch of the beech-drops, bearing short spikes of flowers that bloom and make no seeds. Below them are numerous closed and altogether ugly flowers which make the seeds. Why the pretty ones should be idle, and the plain ones do all the work, I cannot tell, but philosophers in human affairs have often asked the same question.

In the foregoing pages we have so fully investigated the mechanism of the flowers, and learned so many of their ways and means for interchang-

ing pollen, that the student will be equipped to carry forward his investigations along the same lines on his own account—play the Sherlock Holmes to the lilies and the orchids, and exchange the old botany for the new. And I promise that the new line of work will be so enthralling that there will be no more of the analysing, classifying, and filing away of dead, dry specimens, but a pursuit afield of vital facts in the life history of flowers and their affinities, to "catch the manners, living, as they rise."

BEECH-DROPS

CHAPTER VIII

EFFORT AND ACCOMPLISHMENT

BUT we have not yet solved all the mysteries of the flowers, for we shall find many odd contrivances and bewildering habits which are explicable only as accessory to the great, central purpose of cross-fertilisation. And we have not yet fully examined the various lures whereby the flowers attract their insect guests. Nor have we discovered in what manner the pollen conveys to the passive ovule that electric impulse which shall endow it with life.

The student has by this time surely come to look

upon our cherished wild flowers as living creatures with almost human attributes. Their undaunted courage and determination to live in spite of adverse conditions, and their ingenious devices for foiling their enemies, teach a noble lesson.

Plants have first to make a place for themselves and reach out for light, air and nourishment. Then they have to foil the attacks of predatory creatures. It is little short of amazing that such soft and tender things can wage war or evolve defences against aphis, beetles, rodents, birds, cattle, and man; and the methods employed by the plants for self-defence are well worth studying.

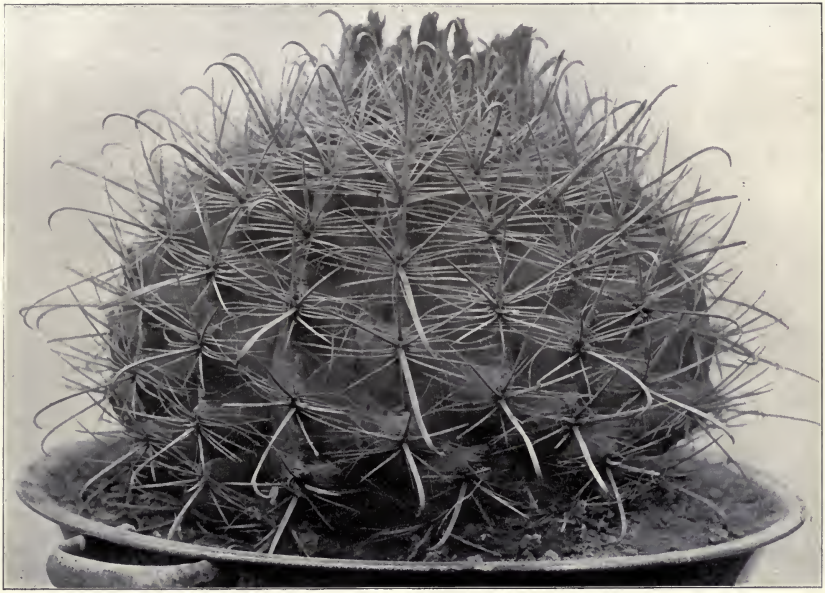
THORNS AND PRICKLES

To ward off the attacks of huge browsing beasts, the plants, trees and shrubs arm themselves with thorns and prickles, as we see in hawthorns and some wild apple-trees. Especially on desert places, where vegetation is sparse, such defence is necessary to survive, and in such regions the plants are thickly covered with cruel spines. The various cacti are so defended, and the Spanish dagger has fierce darts at the tip of each leaf. In the New York Museum of Natural History is an exhibit showing this desert vegetation, with all its array of bristling weapons; and our illustration of a

Turk's-cap cactus, brought from the Mexican border by Major Foulois of the U. S. A. Flying Corps, will show the reader how invulnerable a plant may make itself.

Just as defenceless civilians may take refuge among an armed band of soldiery, so do defenceless plants seek safety among their thorny and prickly kindred, and we find thickets and hedgerows made up of a tangled mass of hawthorns, brambles, and wild roses, interspersed with every kind of soft and tender plant and climbing vine. But there are defences less conspicuous than thorns, yet no less potent. Plants like hardhack, ironweed and vervain build up woody fibre which makes them inedible, and strike deep roots to hold them against removal. The laurel has the woody fibre, and also distils poisonous juices into its leaves as an additional protection. The *Equisetum* stores up particles of silica in its tissues, and hence becomes quite indigestible.

Then, to ward off the smaller pests which creep and crawl, the plants clothe themselves in hairy raiment, or besmear their stems with sticky cosmetics till ants and beetles, slugs and caterpillars, are held at bay. Water is a sure barrier against such enemies, as some plants seem to know. There are plants which, when growing on land, have rough



MEXICAN CACTUS

defences, yet, when standing in shallow water, out of reach, will develop smooth stems.

The teasel thrusts its stem through the united bases of its leaves, as I sometimes jab my pencil through a sheet of paper. The leaves thus form a cistern to catch and hold the raindrops in a pool around the stem so that no creature can climb upward and devour the flower.

TEASEL

Though the ant is often a ruinous visitor, he is not always to be dreaded. In fact, since he is notoriously carnivorous, he actually serves the plants many times by destroying battalions of their worst enemies. It has been estimated that the dwellers in a single ant-hill devour 100,000 plant-pests in a single day. The Chinese know the value of these little allies and, in the Province of Canton, the orange-growers place ant-nests in the orange-trees, with bamboo poles from tree to tree for the ants to use as bridges.

The plants are as wise, for certain thistles exude a sugary liquid outside their buds to attract ants, and these defend the citadel from beetles. An Acacia of one variety bears hollow thorns for little

houses in which ants are happy to dwell—a garrison always on the alert. In Guiana the orchids are especially liable to attack, and some of them form veritable barracks of their roots for an army of ants to occupy. There are as many plant defences as there are locks and safety-contrivances, guns and fortifications, all to prolong life and make blooming and seed-bearing possible, but there are special safeguards to protect the nectar and pollen.

BURGLAR INSURANCE

Besides crawling things, which may be stopped by bristly stem or calyx, there are unwelcome guests who arrive on the wing, and these are often balked by a closed corolla, as we see in the snap-dragon and closed gentian of our coloured plate, which are accessible only to the bee. Again, some flowers serve their nectar in shallow cups from which short-tongued insects, only, can sip, whilst others conceal their sweets in deep and narrow nectaries, accessible to none but the long, prehensile tongues of moths and butterflies

RAIN SHELTERS

While rain is most useful and necessary to the growth of the plant, it is most harmful to the nectar

HONEY GUIDES AND RAIN SHELTERS

and pollen. Accordingly, flowers take great precautions to protect their stores from rain-fall. The arching hoods of the sage, gladiolus and Jack-in-the-Pulpit are one means to this end. Many flowers close, others droop, to shed the rain. But I was at a loss to understand how erect, saucer-shaped flowers like the phlox—veritable funnels—could keep dry in spite of rain, till I inspected my flower-border after a shower and found on the phlox blossoms little pearly drops reposing like crystal spheres at the openings of the nectar wells. The tubes were so small as to be capillary, and thus excluded the drops. I have shown one such floret in the colour plate. The pitcher-plant flower, which covers its pollen with a little green umbrella, is also depicted.

LURES OF FLOWERS

But when the flower has developed, the feast is spread, and the banquet-hall is thrown open, the desirable guests are bidden and cordially welcomed. Gay-coloured banners and penetrating perfumes announce the invitation; rich, soft carpets unroll upon the doorstep, and strongly accentuated posters indicate the exact entrance. These are known as honey-guides, and consist of streaks and blotches

of gayest colours such as we see on the petals of the nasturtium and the pansy, or in the throat of the gladiolus. They correspond to the bull's-eye of the target, or the little red heart embroidered upon the sweater which swordsmen wear in tournaments of fencing.

Much has been written about protective colouring among birds and animals, which melts their plumage or fur into their surroundings and cloaks them with a mantle of invisibility. Now, colouration among the flowers is just the reverse of protective. It is as a trumpet-call to attract attention to them, and to bring faithful insects to do their bidding. For a brief season flowers strive to be as conspicuous as they can, and to outshine their neighbours and their rivals.

Just how much the colour of flowers serves as lures to the insects, we do not know with precision. Darwin, Müller and Lubbock believed it to be very potent, and took great pains to classify insects according to their apparent preferences for one colour or another. But other writers doubt the efficacy of colour as a lure. Gaston Bonnier has published numerous experiments which seem to contradict the belief in the attraction colour exerts upon insects. It is likely that the truth lies somewhere between these two extremes. Insects may be more or less

colour-blind to certain colours, and hence visit only flowers which they see as brilliant ones. Lubbock experimented with dabs of honey on strips of glass over papers of various colours. By shifting the honey and glasses about over the papers, he apparently demonstrated that the honey-bee preferred to alight upon the honey which was over a blue paper.

Kerner tells of observing a similar preference on the part of bees. In the Botanical Gardens of Vienna were two bushes of the *Monarda* in full bloom—the *fistulosa* and the *didyma*. The former, being of a purplish-red, received all the visits of the bees, whilst the latter, of a scarlet-red, was shunned, or at least neglected.

It is certain that the night-moths and other nocturnal insects see by night better than we do. Our day is their night; our night is their day. For them the greater part of the white flowers bloom. Yet they can doubtless see colours well at night, for many moths, on spreading their wings, unfold gorgeous under-wings with which to attract and fascinate their mates.

Now it is a curious fact that brightly coloured butterflies frequent the gayest flowers, often choosing those whose colour corresponds, or at least harmonises, with their own. Why is this? The ex-

planation is that these butterflies seek and prefer a mate with brightly coloured wings, and the same colour-sense leads him to visit, by preference, flowers which are equally resplendent. Our colour plates of the flame azalea and the butterfly-weed were painted to show two of our butterflies visiting favourite flowers.

INSECTS AND THEIR FAVOURITE COLOURS

If insects are necessary to the flowers, the flowers are no less essential to the insects, for the pollen they shed and the nectar they secrete are the normal food for most beetles, bees, moths and butterflies. There was a time in past ages when no flowers bloomed and, also, no bees nor butterflies were on the wing, and, strange to say, when the former appeared the latter also came into existence. Such is the record written in the rocks, and deciphered by scientists wise in those hidden mysteries. Beginning with flowers of simple forms and perhaps colourless and scentless, the scientists have traced a progression upward through stages of growing complexity and increasing opulence, and, parallel with the flowers, they have traced an upward scale of insect-life from blundering beetles, dull in colour as in intelligence, through many forms ending with the frail butterflies, sensitive and resplendent.

The development in the flowers is well illustrated by the gentians. An Alpine gentian, the *lutea,* is a primitive type which has survived. It has a yellow colour and a fully open flower, with almost free access to its nectar. Various insects could enter and sip, and they performed cross-fertilisation casually and irregularly. The form was modified in such a way that bees, especially bumblebees, become the most efficient bearers of the pollen. To suit the bees, then, the bell-shaped flower was evolved and the colour modified to blue to serve as a special attraction. Thus has our beautiful gentian fashioned its festal attire to please its guests.

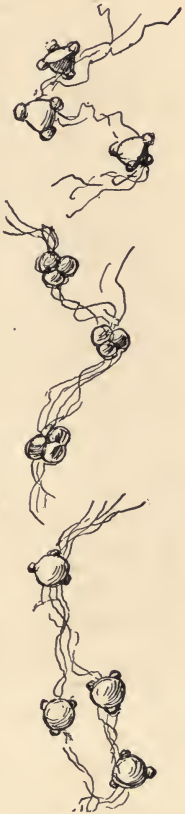
Beetles, the lowest in the scale in regard to the power and adaptability for cross-fertilisation, visit flowers of dark, dull red and violet. They seem to avoid yellow flowers. Flies frequent yellow flowers. Honey-bees and bumblebees have a special liking for blue flowers and generally pass by the scarlet ones without visiting them. Butterflies and moths are the most highly specialised insects for the work of cross-fertilisation, and they display marked intelligence and a keen sense of appreciation for brilliant colours. But the bees do much more of the actual work, from the fact that they carry away loads of pollen with which to feed their young, and in so doing incidentally interchange pollen amongst the flowers.

VARIOUS POLLEN GRAINS

POLLEN

Pollen is not all alike. That from different plants differs much in size, form, and consistency. Grains from the Marvel of Peru measure .22 millimetres, whilst those of the forget-me-not are only .0025 millimetres in diameter. Under the microscope they exhibit most astonishing diversity of form. As a rule they are spherical or spheroidal, that is, elongated like footballs. The pollen-grains of some plants are cubical, and of others, dodecahedrons. The pollen intended to be carried by the wind has usually smooth grains, whilst those destined to cling to insects bear points, spines, and prickles, or else are bedaubed with a sticky and adhesive coating known as "viscin."

Our first sketch, borrowed from Kerner, shows some of the odd and diverse shapes. The viscin acts as a sort of bird-lime to fasten the pollen on the insect; but sometimes it is pulled out in long, slender threads, like spider-webs, to entangle the insect in its meshes. This happens in the case of the *Rhododendron hirsutum,* the evening-primrose, and the fire-weed. Our second sketch shows groups of pollen-grains thus joined by filaments into a tangled net to ensnare the unwary visitor. All pollen-grains are hollow cases containing fluid and living germ-cells. They have a certain independent life of their own, and a power of spontaneous growth, as if they were seeds in their own right. By experiments, the pollen of some flowers has been found to live three days, that of others seventy-six. Pollen of palms and cycads if kept dry



POLLEN GRAINS AND FILAMENTS

may be sent long journeys to fertilise flowers in distant countries. The Arabs save some from their date-palms from year to year to dust the new crop of flowers and insure the very necessary supply of dates. There is a legend that pollen of dates, hemp and maize has kept its vitalising power over a space of eighteen years.

But what happens after the pollen reaches the stigma of a flower? By what mysterious impulse is the thrill of life conveyed from the grain, down through the tissues of the long style, to vivify the soft and inert mass of the little ovule? Very clever observation and manipulation under the microscope has revealed this mystery.

Upon each stigma is a certain amount of moisture, which softens the shell of the pollen grain. It expands and germinates, putting forth a growth called a pollen-tube, which strikes root in the soft fibres of the stigma and forces its way downward through the style. It grows at the expense of the tissues of the pistil, like a parasite plant. Reaching the ovary, where the little ovules are waiting, the pollen-tube usually follows the outer wall, as groping in the dark it reaches down-

FERTILISATION OF FLOWER

ward, around, and upward, till, with unerring aim, it strikes a little opening in the ovary, called the micropyle, or little door, and enters there. Communication thus being established between the pollen-grain above and the ovule below, the vital cells contained in the former flow down the slender pollen-tube, enter the ovule and give it the touch of life which it requires. This last step of the journey is now correctly termed "fertilisation," and all of our previous explanations and descriptions had but to do with the pollination. The ovule, now vitalised, divides its cell tissues into one or more nuclei, and sets apart a portion for a food reserve with which to nourish the future plant. At this stage the pollen may dry, and the flower may fade, but the ovule will proceed to develop into a seed, with all its hope and promise of a new life.

FERTILISATION OF PINE

Ordinarily, the pollen-tube has to traverse a considerable distance through the length of a stigma, more or less elongated, but, in the case of the gymnosperms, as we have already explained, the pollen-grain alights directly at the opening of the ovule, is caught there by a drop of moisture, and is drawn into the opening and germinates within,

sending a very short pollen-tube into the interior cell-structure. The opposite extreme of a pistil enormously elongated is to be seen in the case of the corn represented on page 170. The corn-silk is but a vast number of greatly elongated styles. Each strand of silk starts from its own particular ovule, reaches up to the apex of the cob and emerges in the tassel. Pollen-grains falling upon the terminal stigma must send their slender pollen-tubes and vital cells down the whole length of the slender strand of silk and reach the ovary; otherwise, no kernel of corn will be formed. The marvel of this performance and of its myriad repetitions needs no emphasis nor comment.

CHAPTER IX

SEED SOWING

OUR wild flowers have grown, bloomed, and made their seeds; but their work is not yet finished, and we have not yet done with the mysteries of their lives.

In writing of seed-making, we have shown that the struggle for a living, and the attracting of insect visitors, is a serious and strenuous business; but when seeds are ripe to be sown it seems that a leisure time has arrived, when our plants may indulge in various sports, much like the recrea-

tions of our Leisure Class. Swimming, diving, motoring, flying, shooting, travelling, are some of those in which the plants and their seeds indulge.

Let us examine the playful and boisterous manners of seed-sowing that have planted a whole continent. We know, of course, that the ripened seeds might fall close about the roots of the parent plant, and grow in a thick mat of a foot or so in diameter where they fell. But the many seedlings would crowd and starve one another, any small local accident would exterminate them all, and any narrow barrier of rock or water or unfavourable soil would completely bar their spreading into new regions. We know that plants have travelled far, for many introduced from Europe—such as the daisies—have swept over fields and mountains to the prairies of the Middle West, where they are now waging a border warfare with native plants there. Supposing that they had come over with the Pilgrims, and had started their migration from the famous Plymouth Rock. Spreading landward at the rate of a foot a year, the farthest limits of their progress would scarcely have reached three hundred feet from the starting-point. If a million years had elapsed since their coming, the same slow means of travel would but have carried them about one hundred and ninety miles.

There evidently must be other more efficient means for scattering seeds than shaking them out of the seed-pods upon the ground near by. Let us examine some of these mysterious methods.

PEPPER-BOX SEEDS

In the sketch is shown the dried seed-pod of a poppy, like a pepper-box on a tall, stiff stalk. Now, to get the pepper for our meat we have to invert and shake the box. How do the loose seeds get out of theirs? Pull the pod a little and then let it spring away, and you will hear the seeds scatter a long way in every direction. But the wind is able to sway these pods back and forth, and, catching the seeds, bear them far and scatter them well.

POPPY

We can find a great many of these "pepper-box" plants in action, such as the monkshood, columbine, larkspur, Jimson-weed. The lilies and the Indian-pipe belong to this class, but they have this peculiarity, that, even though their corollas may turn modestly downward while in bloom, yet

INDIAN-PIPE

they turn their dry seed-pods straight up into the air. This is to prevent a sudden discharge of the seeds all at once and to make sure to shake them out in small quantities when the breezes come along. This change in the Indian-pipe from a drooping and white flower to a brown and erect seed-pod having the form of a little brown jug is so great a transformation as quite to disguise the plant and perhaps to make us imagine that we have found a new species altogether.

Seeds must generally be kept carefully dry till they are sown; hence the corrugated roof of the poppy box, above described. But the lady's slipper pod, which also is a "pepper-box," holds its seeds tight and dry during moist weather but on sunny and windy days opens through slits up and down its length and shakes out its fine contents. The sketch shows such a pod, externally and in cross-section, with long, narrow lids which open or close over

LADY'S SLIPPER

the openings, in response to the changes of weather.

AIR GLIDERS

No one knows how long ago ambitious navigators learned to hitch their frail barques to the sea breeze to carry their cargoes, but it is certain that in very early ages the pines and other tall trees learned to take advantage of the wind in like manner, as a means of spreading their seeds. So each seed was built like a biplane, or air glider, as we have seen in a previous chapter. A seed of the pine, with its small sail, was represented in our sketch on page 166. That of the maple, much larger and very familiar, is shown here. We have all seen them floating down from maple-trees, and twirling as they slowly fell. The lightest breeze can carry them a long way ere they reach the ground. We find similar seed-sowing practised by the elm, ash, birch, hornbeam, linden and catalpa.

MAPLE

AIRSHIP SEEDS

But these gliders are comparatively heavy seeds. There are many others far lighter for their dis-

placement, which become veritable airships. We can scarcely imagine a thing lighter than thistle-down, or its like among the seeds. Our sketch at the beginning of this chapter shows seed vessels and seeds of the clematis, milkweed, fire-weed, and dandelion.

Boys who fly kites know full well that the wind, blowing over uneven ground, does not travel in a horizontal plane but rises at every slope, sweeps up over every hedge or obstruction, and thus can easily pick up and whirl away these little, feathery seeds and scatter them over a whole county. Most of these very light seeds, it will be noted, grow upon herbs near the ground.

TUMBLE WEEDS

TUMBLE WEEDS

But the wind furnishes power to scatter seeds of some plants in another odd and remarkable fashion. Certain plants, known as tumble weeds, on maturing dry up and break loose from their roots. They then travel over the ground like automobiles, driven by the wind. As they go, they scatter their seeds all along their paths. The best known of these plants is the tumble weed (*Amarantus graecizans*) of the Middle West, a sketch of which is shown here. It is said to be most fantastic, the action of a whole field full of these weeds, how they all scurry in one direction, lodge under the windward side of a fence, then suddenly leap the barrier like a flock of scared sheep following a leader, or fleeing from some imaginary danger.

The *Amarantus biltoides,* a near kin to the tumble weed, though chiefly to be found west of the Mississippi, occurs occasionally beside railway lines in the East, having come in with the railroad ballast, which goes to prove that our plants take advantage of the most improved methods for shipping their seeds.

QUEEN ANNE'S LACE

Queen Anne's lace, or wild carrot, converts its dried flower-head into a kind of tumble weed. As the seeds ripen you will notice that the flower-cluster, originally a beautiful, flat cyme, curls inward, and looks like a bird's nest, full of seeds. Sometimes closing tightly into a ball, it eventually breaks from the parent stem, and, in winter, goes rolling and gliding over the snow. As it travels thus, the seeds are shaken out as from a loose basket and are distributed over fields and pastures, where they cause no end of trouble to the farmers.

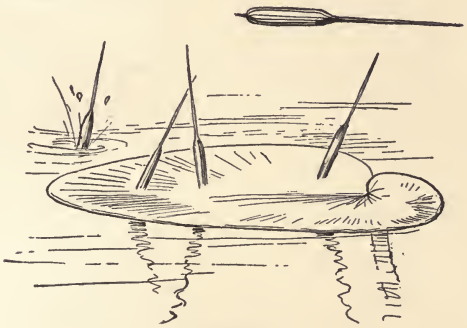
There are other less conspicuous tumble weeds, such as the Rose of Jericho, the Russian thistle, tickle-grass, and peppergrass (*Lepedium*), some of which may be found in our locality.

But while the wind can carry its burthen fast and far, much of its cargo is wasted. As in the Parable of the Sower, many of the seeds thus transported fall into unfavourable situations, and come to nought. Water traffic is a slower but surer means of carriage.

SEEDS CARRIED BY WATER

Seeds that grow beside the river's brink, and fall into its tide, will be carried to other shores where their environment will be favourable. No

one can tell what myriads of moisture-loving plants are thus spread along our river shores. I have found seeds of the skunk cabbage bobbing and floating with the current; marsh marigold and cardinal flower doubtless follow the same road; and the bladderwort and pondweeds break off their buds and shoots and send them floating away, just as we send cuttings of our own plants to be sprouted by distant friends.



WILD RICE

The rain, also, helps in seed dispersal, especially in the case of the yellow stonecrop, which it thus plants in the deep crannies of rocks. The Veronica also avoids wind dispersal of its seeds by keeping its capsule closed till a shower comes. Then they are shed, and are carried by trickling rills of rain to low, moist places such as they require.

But all seeds will not swim. Some are made to dive. An interesting instance of these diving seeds occurs in the wild rice. Beside my pond I planted some as an ornament, and it flourished and increased enormously, but never spread downstream, as I expected it to do. Here was a mystery which ultimately explained itself. One day, when I accidentally jostled a stalk of the plant, shaking off a swarm of ripe seeds, all, or nearly all, of them fell into the pond and plunged to the bottom. A few, only, stuck point downward into the floating lily-pads, like javelins in a warrior's shield. Examining these seeds, I found that each was like a rocket, with pointed head and long stick, arranged evidently to strike the water point downward. Now it is a known fact that wild rice seed, once it is dried, will no longer germinate; hence all these precautions are to make sure that the seeds shall be planted underwater.

SEEDS DISPERSED BY BIRDS AND ANIMALS

We have seen how plants enlist the co-operation of insects to carry their pollen, but, later in the season, they will be found often to employ larger and stronger creatures to bear the burden of their seeds, fruits, and nuts. Very small seeds, it is true,

are carried away by ants to their lairs, for whose convenience, it is said, the blood-root grows two little handles upon its seeds; but birds are, perhaps, the more active seed-sowers.

Strawberries, raspberries, checker and partridge berries, all are favourite foods for birds; but their seeds, with woody coverings, are indigestible and are dropped under trees and shrubs where they germinate the following year. Berries like those of the mistletoe are exceedingly gummy, so that they attach to the bird's beak till they are wiped off upon some branch, there to cling and grow.

Seeds also cling to the muddy feet of wild-fowl, for transportation free and far, like naughty boys taking a "hitch" behind. The following observations made by Darwin are illuminating:

He was given the leg of a red-legged partridge, which had adhering to it a ball of earth weighing six and a half ounces. The specimen was already three years old, but Darwin soaked the earth, planted it under a bell-glass, and sprouted 82 young plants, apparently of three distinct species.

We have learned that water-plants send their seeds downstream, but the water-fowl are very likely the agents which carry them in the opposite direction. Thus, maybe, the fine seeds of our beau-

tiful cardinal flower were carried up to the headwaters of our many narrow brooks and streams.

EDIBLE FRUITS AND SEEDS

Most berries and fruits take on brilliant and attractive colours as they ripen, making an irresistible appeal to the eye as well as to the appetite. The reader will remember the dramatic story of Buddha, who came face to face with a mother tiger, famished and madly seeking food for her young, and how the Prince, making a supreme sacrifice of his own body, permitted the tigress to devour him, knowing full well that he should have another reincarnation. This legend finds a striking parallel in the lives of those plants which offer their lucious fruits to be eaten, thereby seeking a reincarnation and renewal of life.

The rose "pips" and hawthorn "haws," the bunchberries and the fruits of false Solomon's seal, strawberries, raspberries, and cherries are but the most common and familiar examples of an enormous class of showy and attractive fruits.

POISONOUS FRUITS

It is well known that some fruits are poisonous, and, as Nature is never uselessly and vindictively

cruel, we must seek some explanation that shall show these toxic berries to be of actual service to the plant in its struggle for existence. A very plausible theory is that the poison kills birds and small animals in order that the seeds shall grow in a soil enriched by the decaying carcass.

There are not as many poisonous fruits in our region as some people imagine. A bulletin issued by the United States Government on the subject mentions but three to be avoided: namely, the nightshade, Jimson-weed, and bittersweet, but omits to mention Jack-in-the-Pulpit, which is said to be poisonous to birds, if not to man, and should never be risked. The purpose of the poison in Jack's particularly gorgeous berries is singularly interesting. Jack-in-the-Pulpit, as we all know, loves to dwell in moist places, and he wants his seeds to be scattered in swamps and near river-brinks, and he seems to know that birds who eat poisonous seeds will be very thirsty, will seek the waterside for drink, and, perhaps dying there, will thereby plant his seeds in a most favourable location.

Nuts may roll down the hillside, or be carried by freshets to new localities, but undoubtedly a vast number of walnuts, chestnuts, and acorns are planted by squirrels. These little animals, besides forming winter stores, have a way of planting nuts

one by one, over large areas, trusting to find them again by the guidance of their instinct. But it is certain that many nuts thus planted are forgotten and are left to grow into stately trees. Apple-trees are spread in a curious way. The squirrels gather the apples and, carrying them up into various trees, jam them into the forks of branches. I have thus seen a maple-tree bearing a crop of wild apples, with one apple snugly brooding in a deserted bird's nest. The fruit will decay or dry, but what the squirrels want are the seeds, and some of them they accidentally let fall.

TRAMP SEEDS

Plants use still another scheme to induce beasts and even men to carry and scatter their seeds. The

TRAMP SEEDS

burrs and ticks and all the annoying things which cling to our clothes, or mat the hair of cattle and

MARTYNIA

the wool of sheep, are but examples of this opportunist policy of the plants, seeking a means to send forth their seeds into far fields and pastures new. Returning from a walk, we can gather from our tweed suit or woollen stockings a choice collection of seeds of burdock, beggar-ticks, agrimony, or bedstraw. Some of these tramp seeds are shown in the adjoining sketch. The *Martynia,* or unicorn-plant, produces perhaps the largest of any of these clinging seed-vessels, and the most curious in appearance. These consist of a recepticle terminating in a pair of black horns, hard, strong, and much curved. In size and appearance they seem as if they must have been shed by some small antelope. The curved points catch upon any being who passes, and the seeds are shaken out through an opening at the base, where the horns split apart. The *Martynia* grows in Indiana and through the West to northern Mexico, but it also is cultivated and naturalised northward.

An interesting tale is told of a royal gift which unintentionally brought about seed-dispersal as its corollary. A buffalo was sent to the King of Ter-

CACTUS
Thorns and Hook

nate, in the Malay Archipelago, from another locality. In the hairy tail of the buffalo were tangled numerous needle-like fruits of a beard-grass, the *Andropogon acicularis.* These seeds took root in their new environment and the beard-grass soon spread over the entire island. As I was writing the present chapter I was invited to inspect a beautiful specimen of a cactus which had just arrived in town from the Mexican Border. I found a few rather inconspicuous flowers, crowning a huge, corrugated dome, green, fleshy, and succulent. The ribs or fins of the dome were bristling with rosettes of fierce spines, and on each rosette appeared a cruel hook. The spines were for defence, and would discourage the approach of any browsing animal, but the hooks were for another purpose, and were not so cruel as they seemed. They were much longer than the spines and could fasten themselves into the hairy coat of a passing animal, and, holding fast, would pull away from the parent stem, bringing with them a little fragment of the

plant, also, to become a cutting that would sprout wherever accident should plant it, for we know how easily fragments of the cacti take root from cuttings.

WILD GERANIUM

CATAPULT SEEDS

The foregoing methods of seed and plant dispersal all depend upon some outside agency, but there are many plants so self-reliant that they attend to their own seed-sowing, which they accomplish by means of various slings and catapults of their invention.

The wild geranium as it "goes to seed" develops its pistil into a long cylinder, inside of which stiff springs are formed, each spring connected with a small seed-pod at the calyx. In this state, the seed-pod and calyx strongly resemble a miniature candle in a candle-stick, as shown in the sketch on the left. When sufficiently ripe and dry, however, the little springs gain force enough to burst out of their places and to curl up suddenly, thus shooting the seeds off in every direction and a long distance

away. This action transforms the appearance of the seed-pod completely, and we now see it, as in the sketch, where the little springs are curled up all around the central axis.

Several of the Bean family, the lupin, vetch, wistaria, shoot their seeds by a sudden bursting and curling of their pods. The pods are made up of two layers of tissue, the outer one of which, in drying, shrinks less than the inner. Thus there is a tendency to curl inward, and when the stress becomes too great, the explosion occurs. The pod opens from tip to stem, its two sides curl suddenly, and the seeds are ejected with force. The change is most magical, for, at a touch, we behold the simple, narrow pod suddenly assume the shape of a pair of twisted horns, and we hear the patter of dry seeds, falling far and near.

LUPIN

The jewel weed, very appropriately called "Touch-me-not," acts in a very similar manner, save that its pod curls downward, from stem to tip. There is a thick axis along which the seeds grow, surrounded by a pod resembling a small bean-

pod. While both seeds and pods are still green the latter separates in longitudinal strips, all of which are ready, at the slightest touch, to curl downward into tight coils. The action is so sudden, the flight of seeds so amazingly quick, we cannot tell what has happened, but we hear the seeds falling like raindrops all about, and we see the shreds of the pod, curled up like helical watch-springs, dangling at the lower end of the axis.

JEWEL-WEED

Some writers say that few of these seeds germinate, but I am inclined to think that this is an error, for the jewel-weed grows so profusely in moist places that it makes a veritable tangle.

The Fraxinilla, Dictamnus, or gas-plant, forms a very pretty seed-vessel like a star-shaped flower, whose lining becomes five small, hard pods, one in each point of the star. These little pods act very much like lupin pods. When they dry, their points curl back, and all their contents are hurled forth with force.

FRAXINILLA

SPIDER-FLOWER

SPIDER-FLOWER
Cleome-spinosa
July-August

A curious flower, introduced from the tropics, flourishing amazingly in our gardens, and often escaping into waste places. The plant always has a shabby, unfinished appearance, as buds, blooms, and spindling, straggling seed-vessels seem to outstrip the foliage. The seed-pods are borne on exceedingly long and slender stems. They consist of two very loose lids enclosing a loop full of seeds. The two lids tend, in drying, to curl back from stem to tip, which they do with violence, when very slightly jostled, throwing the many seeds in every direction. The spider-flower is worth growing for the mere fun of seeing the pods explode.

The shooting of seeds so far described is accomplished by a genuine catapult movement of a stiff spring, or springs, held in tension and suddenly released. But another way of shooting seeds is through compression. The inner lining of the seed-vessel shrinks and pinches the seed till it "flips" out,

WITCH-HAZEL

exactly as a cherry-pit is "flipped" between the finger and thumb. The operation can be studied on a large scale in pods of the witch-hazel. For a whole year the little round seed-vessels have been growing and perfecting their twin charges of seed, when, late in October, they split across and open like an elfin mouth. Within, we see two divisions, each with a hard, brown lining, and a shining black seed. The mouth opens wider, the lining pinches together, when, without warning, the seed is "flipped" and gone. Mr. Gibson, by experimenting in a quiet room, found that the witch-hazel seeds could fly as far as thirty feet.

The pansy and violet form a globular seed-vessel which later splits into three widely spreading seed-pods. Then each little pod dries and pinches its closely packed contents, till at length the pressure becomes too strong to endure, and all hop out and scatter.

PANSY

The wood-sorrel forms a long,

pointed seed-vessel, resembling that of the garden ochra on a very minute scale. Its five longitudinal divisions are shown in our sketch of a cross-section, and these open outward along their whole length.

WOOD-SORREL

The drying and shrinking of the seed-vessel pinches the lines of seeds till they escape from their contracting prison-cells, and seek freedom in flight.

In Europe grows a curious plant, a member of the Gourd family, known as the squirting cucumber. I have never seen it, but I find the description of its antics exceedingly interesting, as given by Kerner. It is known to the botanists as *Ecballium elaterium*. The fruit is like a bomb charged with seeds in a soft, mucilaginous mass. In the walls of the fruit is a layer of cells under great tension, which exerts pres-

SQUIRTING CUCUMBER
(After Kerner)

sure upon the semi-fluid contents. The stem attachment projects into the fruit like a stopper. But when the fruit is quite ripe it separates from this stopper, and through the hole thus opened the compressed contents are ejected, and the seeds fired a long way.

I imagined, and fondly hoped to find, that our wild balsam-apple would display similar antics, but I have studied carefully the odd, prickly fruit and find that it clings to the vines, but opens at the lower extremity to drop its slippery seeds upon the ground.

WILD BALSAM-APPLE

We have now examined many of the ways whereby plants have spread. Flying, jumping, clinging, swimming, they have travelled incredible distances, and have sought out every available spot from Pole to Pole. But not alone by short and uncertain stages have they travelled. The grandest and mightiest forces of Nature have lent their aid to seed and plant distribution, and by their operation we can explain some of the mysterious migrations of plants, and their appearance

in regions far asunder. We think of the ocean as a vast barrier, yet the tidal streams may bridge its expanse and bear the flora from continent to continent.

Accordingly, the first question which presents itself is this: Can seeds survive immersion in sea-water, and for how long a time? To answer this double question, Darwin soaked seeds of eighty-seven varieties of plants in sea-water for twenty-eight days and then planted them, with the result that sixty-four kinds sprouted. Other experiments of like nature proved that 14 per cent. of seeds and fruits retained their vitality in salt-water so well that they could be carried by the ocean currents for a distance of 924 miles, and grow upon a distant land.

Drifting trees often carry stones and earth entangled in their roots, and thus may act as carriers of seeds. Land birds, with their crops full of seeds, are often driven out to perish upon the ocean, and their bodies become argosies freighted with germs of flowers and weeds that will germinate on some far-away shore. Icebergs are known often to carry cargoes of earth and boulders, with sods, roots, and seeds. Here again is a means of far dissemination. On the Azores are found strange

boulders thus transported, and also numerous plants brought from northern regions. Thus Nature gives her children a chance to travel the wide world and seek their fortunes, and acclimatise themselves, if they can, in new-found fields.

But another mystery of the flowers appears in the presence of Alpine flowers on mountain tops of Europe and America, with none of their kind on the intervening lowlands, yet bearing a relation with the Arctic flora in regions directly north of their habitat. Thus plants on isolated mountain peaks of the United States and Labrador resemble the Arctic plants of the Western hemisphere, and those growing in Alps and Pyrenees resemble those of the Eastern, and many are common to both. The strange isolation and kinship of these mountain plants is explained as follows:

Before the Glacial Period a warmer climate prevailed in the Northern hemisphere than at present, and the temperate zone reached much farther north, so that plant forms of that zone dwelt farther north and peopled a part of what we now call the Arctic continent, and flourished uniformly over the polar regions. Then, gradually, great fields of ice and snow pushed southward from the Pole and crept downward from mountain peaks to verdant valleys. All tender and temperate plants decamped

and moved southward before the icy invasion, just as the peoples of Europe fled before the invasion of the Huns, but those Arctic plants inured to the cold, and loving the proximity of ice and snow, retreated in a more orderly fashion and formed a rear-guard against the advance.

When the Glacial Epoch was passing, and the frontier of ice and snow was withdrawing northward, the Arctic flora followed closely upon the line of retreat, or climbed to the cool peaks of mountains. The plants of more tender habits spread around the bases of these mountains and followed as far as climate would permit. Thus colonies of Arctic stock were isolated on mountains, yet through long ages keep their close resemblance to kin on distant ranges, or polar plains. The less hardy plants which had moved southward could not, on returning, traverse high and cold mountain barriers. Hence, we see in Europe that the Alps and Apennines, running East and West, were a bar to progress northward, whilst in the United States, where mountain chains run from North to South, no such barriers are opposed and we can thus understand why we possess so much richer and more varied flora.

The epic of flower-wanderings has not yet been written. We should like to know how it came about

that our beloved Wild Flowers of the Eastern States are like those of Japan. I have a book of Japanese prints of flowers which might be used to illustrate an American botany. The migration of *Shortia* from Japan to one little patch in our Alleghanies would be thrilling to peruse. The story of its discovery by Micheaux, its loss for a century, and its rediscovery are told most entertainingly by Miss Lounsberry in "Southern Wild Flowers and Trees."

Courageously and through long ages, and in spite of many vicissitudes, our lovely Wild Flowers have survived, and I wish to say a word in their defence before I lay down my pen.

When a new book on botany appears it is apt to send an army of so-called "flower-lovers" charging down, uprooting, and exterminating our choicest and rarest specimens. Let me vehemently express the hope that no such ravages will follow the unveiling of the "Mysteries of the Flowers." Europeans reproach the Americans with a want of the sense of proportion, and what can we say in our defence? We have laid waste our rarest inheritance. We have netted nearly every trout, shot most of our game and many song-birds as well, skinned nearly every beaver, otter and seal, exterminated the buffalo, and now we gather our

orchids by the armful and pull the arbutus by the roots, till whole counties know them no more.

These Wild Flowers are Nature's jewels, and we should have learned that an excessive display of jewels is vulgar. One orchid is much better than a dozen. Its beauty can be enjoyed, and its long and distinguished lineage need not be extinguished, nor the efforts and progress of ages wither in our hands. To study the mystery of a flower, one or two specimens are sufficient for dissection, supplemented by close observation of growing ones and of their insect guests. In order to make the studies of the rarer flowers for this volume, I have carried my outfit for many a mile to sketch them where they grew. I beg the reader likewise to spare our vanishing Wild Flowers, lest they follow the fairies and disappear.

TRAILING ARBUTUS

INDEX

INDEX

Acorus calamus, 22
Aesculus hippocastanum, 48
Alisma plantago-aquatica, 42
Allen, Grant, 23
Amarantus, 209
Andromeda ligustrina, 109
Andropogon acicularis, 218
Anemone quinquefolia, 34
Angelica, 72
Angiospermous Flowers, 165
Anthers, 5
Apios tuberosa, 107
Apocynum androsæmifolium, 126
Apple, 68
Arethusa bulbosa, 153
Arisæma triphyllum, 18
Aristolochia sipho, 119
Arrow Head, 30
Arum maculatum, 19
Aruncus sylvester, 26
Asclepias syriaca, 120
Asparagus, 16
Azalea, Clammy, 45
" Flame, 45
" Pink, 44

Balsam Apple, 29
Baneberry, 66
Barberry, 114, 178
Bean Family, 104
Beard-Grass, 218
Bee-Balm, 91
Beech Drops, 187
Bellflower, 77
Berberis vulgaris, 114
Birthroot, 49
Black-Eyed Susan, 98
Blackberry, 176
Bladderwort, 211
Blazing Star, 17
Blue Curls, 80
Blue-Eyed Grass, 50
Bluet, 54
Bog Orchis, Tall White, 145
" " Southern, 156
Bonnier, Gaston, 194
Bouncing Bet, 70
Brassica arvensis, 41
Burbank, 179
Burr-Reed, 172
Butterfly-Weed, 126

Cactus, 189, 218
Calla palustris, 22
" White, 23
Calopogon pulchellus, 157
Caltha palustris, 40
Campanula, 77, 177
Canterbury-Bell, 79
Cardinal Flower, 95, 211
Catch-Fly, Night-flowering, 71
Chamælirium luteum, 17
Chelone glabra, 84
Chestnut, 168

Cleistogamous Flowers, 185
Clematis virginiana, 24, 208
Cleome spinosa, 222
Clover, 106
Cohosh, Blue, 66
Collinsonia canadensis, 65
Composite Family, 99
Convolvulus sepium, 37
Corallorrhiza, 154
Coral Root, 154
Corn, 170
Cornus florida, 36
Cranesbill, 8, 66
Cross Fertilisation, 9
Cycad, 199
Cypripedium Acaule, 133
" *arietinum*, 136
" *candidum*, 136
" *hirsutum*, 135
" *parviflorum*, 137

Dalbardia, 186
Daisy, Ox-Eye, 100
Darwin, 9, 194, 213, 226
Desmodium nudiflorum, 108
Devil's Bit, 17
Dichogamous Flowers, 14, 57
Dimorphic Flowers, 55
Depford Pink, 180
Diœcious Flowers, 13
Dogbane Spreading, 126
Dog-tooth Violet, 176
Dogwood, 36
Duckweed, 180
Dutchman's Pipe, 119

Echinocystis lobata, 29
Ecballium elaterium, 224
Eel Grass, 26
Elder, 41
Epilobium angustifolium, 67
Epipactis, 147
Equisetum, 190
Eupatorium purpureum, 96
Euphorbia pulcherrima, 116
Evening Primrose, 199

Ferguson, M. C., 167
Figwort, 62
Filament, 5
Fire-Weed, 67, 199, 208
Flag, Blue, 86
Flax, 57
Forget-Me-Not, 43
Frostweed, 186
Foxglove, Downy False, 103
Fraxinilla, 221

Genista tinctoria, 109
Gentian, 177
" Alpine, 197
" *andrewsii*, 73
" Closed, 73
" *crinita*, 73
" *lutea*, 197
Geradia flava, 103
Geranium, Garden, 55
" *maculatum*, 66
" Wild, 66
Gibson, W. H., 65, 109, 156, 184, 223
Goat's Beard, 26
Gourd, 28
Grape, 24
Grass Pink, 157
Gray, Asa, 60, 158
Grew, Nehemiah, 4
Ground Nut, 107
Gymnospermous Flowers, 164
Gyrostachys, 149

Habenaria dilatata, 145
" *flava,* 146
" *Hookeriana,* 144
" *hyperborea,* 145
" *lacera,* 147
" *nivea,* 156
" *orbiculata,* 142
" *psycodes,* 141
Hardhack, 36
Heath Family, 109
Hedge Bindweed, 37
Hibiscus moscheutos, 50
Honey Guides, 11
Honeysuckle, Trumpet, 46
Houstonia cærulea, 54
Hooker's Orchis, 144
Hop Vine, 169
Horse-Balm, 65
Horse-Chestnut, 48
Hypoxis hirsuta, 42
Hypericum, 35

Impatiens biflora, 117
Indian Pipe, 206
Iris versicolor, 86

Jack-in-the-Pulpit, 215
Jewel-Weed, 117, 186, 220
Jimson-Weed, 102
Joe Pye Weed, 96

Kalmia latifolia, 47, 112
Kerner, 195, 224

Laurel, Great, 47
" Mountain, 47, 112
Lady's Slipper, 206
" " Pink, 133
Lady's Slipper, Ram's Head, 136
" " Showy, 135
" " White, 136
" " Yellow, 137
Lady's Tresses, 149
Lemna, 180
Lily, 21, 176
Linum grandiflorum, 57
Linum flavium, 57
Linnæus, 4
Lion's Foot, 98
Liparis lilifolia, 154
Lobelia cardinalis, 95
" Pale Spiked, 94
" *spicata,* 94
Lonicera caprifolium, 46
Lords and Ladies, 19
Loosestrife, Purple Spiked, 57
Lounsberry, A., 229
Lubbock, 194
Ludwig, F., 181
Lungwort, Virginia, 43
Lupin, 220
Lythrum salicaria, 57

Male Berry, 109
Mallow, Common, 35
" Roundleaf, 178
Malus, 68
Malva rotundifolia, 35, 178
Maple, 207
Marsh Marigold, 40, 211
Martynia, 217
Matthews, Schuyler, 31
Mechanism of Flowers, 82
Mertensia virginica, 43
Micheaux, 229
Milkweed, 120, 208
Mimulus ringens, 90
Mint Family, 79

Mistletoe, 213
Moccasin Flower, 133
Monarda, 91, 195
Monkey-Flower, 90
Monœcious Flowers, 28
Mullein, Greater, 61
Müller, H., 125, 194
Mulberry, 172
Mustard, Field, 41
Myosotis palustris, 43

Nettle, 172
Nicotiana longiflora, 69
Night Shade, 102
Nymphœa advena, 64

Orchids, 128
Orchis, Hooker's, 144
Orchis rotundifolia, 140
" Round-leaved, 140
" Small, 146
" *spectabilis,* 137
" Tall Green, 145
Orchis, Tall White, 145
Oswego Tea, 91
Ovule, 4
Oxalis, 57

Palm, 199
Pansy, 100, 223
Partridge Berry, 56
Pea, Sweet, 105
Pear, 68
Pelletory, 172
Pepper-Box Seeds, 205
Peppergrass, 210
Perfect Flower, 33
Pickerel-Weed, 57
Pine, 165
Pistil, 5
Pitcher-Plant, 51
Plantago lanceolata, 59
" *major,* 60
Plantain, 172
" Common, 60
" English, 59
" Water, 42
Platycodon, 79
Pogonia ophioglossoides, 8, 151
" *verticillata,* 152
Poinsettia, 116
Pollen, 2, 55, 199
Pollination, 9, 201
Polygala, Fringed, 186
" *sanguinea,* 81
Pond Lily, Yellow, 64
Pondweed, 211
Pontederia, 57
Poppy, 205
Prenanthis serpentaria, 98
Primrose, 57
Proterandrous Dichogamy, 66
Proterogynous Dichogamy, 59
Prunella vulgaris, 79
Purple Fringed Orchid, 141
Pyrola elliptica, 48
Pyrus, 68

Quaker Lady, 54
Queen Anne's Lace, 210

Ragged Fringed Orchid, 147
Ragweed, 171
Rain Shelters, 11, 192
Raspberry, Virginia, 176
Rattlesnake Plantain, 147
Rhododendron hirsutum, 199
" *maximum,* 47
" *nudiflorum,* 44
" *viscosum,* 45

Rib Grass, 59
Richardia, 23
Richweed, 64
Riley, C. V., 182
Ripple Grass, 59
Rose Family, 176
Rose of Jericho, 210
Rose Pogonia, 151
Robertson, Prof., 64
Round-leaved Orchis, 144
Rue, Tall Meadow, 25
Russian Thistle, 210

Sage, 92
Sagittaria, 30
Saint John's Wort, 35, 180
Salvia officinalis, 92
Sambucus canadensis, 41
Saponaria officinalis, 70
Sarracenia purpurea, 51
Scrophularia marilandica, 62
Scutellaria, 79
Seed Dispersal, 203
Self-Fertilised Flowers, 176
Self-Heal, 79
Shinleaf, 48
Shortia, 229
Showy Orchid, 137
Silene noctiflora, 71
Sisyrinchium angustifolium, 50
Shepherd's Purse, 179
Skunk Cabbage, 211
Snake-Mouth Pogonia, 151
Soapwort, 70
Solanum dulcamara, 102
Solomon's Seal, 180
Spanish Bayonet, 181
" Dagger, 189
Sphagnum Moors, 51
Spider-Flower, 222
Spiderwort, 36
Spirea tomentosa, 36
Sprengel, Theory of, 6
Squirting Cucumber, 224
Stamen, 5
Star Grass, Yellow, 42
Steeple Bush, 36
Stonecrop, 211
Stigma, 5
Strawberry, 8
Swamp Rose-Mallow, 50
Sweet Flag, 22

Tape Grass, 26
Tecoma radicans, 88
Teasel, 191
Thalictrum polygamum, 25
Thorns, 189
Tick Trefoil, 108
Tickle-Grass, 210
Timothy, 168
Tradescantia virginiana, 36
Trichostema dichotomum, 80
Trillium, 6, 49, 176
Trimorphic Flowers, 57
Trumpet-Creeper, 88
Tobacco, Long-Flowered, 69
Touch-Me-Not, 117
Tubercled Orchis, 146
Tulip Tree Flower, 6
Tumble Weed, 209
Turtle-Head, 84
Twayblades, Lily-leaved, 154

Umbelliferae, 72

Vallisneria spiralis, 26
Venus' Looking-Glass, 79, 186
Verbascum thapsius, 61
Veronica, 211

Vetch, 220
Violet, 100, 185
Wake-Robin, 49
Water Arum, 22
Water Lily, White, 35
Whin, 109
Whitlow Grass, 179, 186
Whorled Pogonia, 152
Wild Balsam Apple, 225
Wild Bean, 186
Wild Carrot, 210
Wild Geranium, 219
Wild Rice, 211
Williams, Dr. H. S., 105
Willow, 16
Willow-Herb, Great, 67
Wind Fertilisation, 162
Windflower, 34
Wistaria, 220
Witch Hazel, 223
Wood Anemone, 34, 179
Wood, Prof. A., 125
Wood Sorrel, 57, 186, 224

Yucca, 181

University of California
SOUTHERN REGIONAL LIBRARY FACILITY
405 Hilgard Avenue, Los Angeles, CA 90024-1388
Return this material to the library
from which it was borrowed.

UC SOUTHERN REGIONAL LIBRARY FACILITY
A 000 669 066 3